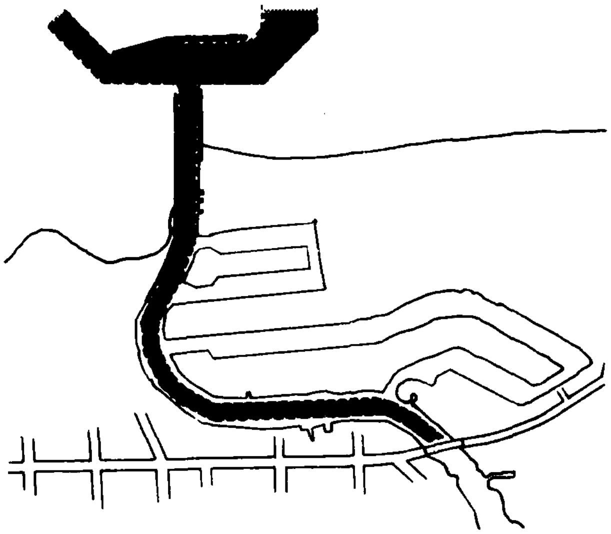
VERMILION HARBOR, OHIO

DETAILED PROJECT REPORT ON SECTION 111

SHORE EROSION STUDY

STAGE 3 DOCUMENTATION



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BUFFALO DISTRICT
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September 1982

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Vermilion Harbor, located on the south shore of Lake Erie approximately 37 mi. west of Cleveland, Ohio was originally constructed by the federal government in 1836 for commercial navigation. The navigation channels were later improved in 1875, 1878, and 1973. The latest improvement (1973) consisted of widening and deepening, and construction of a cellular steel sheet pile detached breakwater located approximately 300 feet offshore. During and subsequent to this latest construction, there have been repeated complaints from local

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residents and other interested groups that the breakwater has caused adverse impacts to the adjacent shoreline. As a result of these complaints the Corps of Engineers carried out an extensive study of the impact of the breakwater on shoreline erosion. The Corps recommended that no mitigative plan be implemented for the shores updrift and downdrift of the Vermilion Harbor entrance structures.

VERMILION HARBOR, OHIO
DETAILED PROJECT REPORT ON
SECTION 111
SHORE EROSION STUDY

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ACKNOWLEDGEMENT

Several people on the Buffalo District technical staff, other Federal and non-Federal agencies, and individuals have contributed to the preparation of this Stage 3 Draft Detailed Project Report on the study of the impact of the Federal navigation structure at Vermilion Harbor, OH, on the adjacent Lake Erie shore. Their efforts, contributions, and cooperation to this investigation since initiation of this impact study in 1976 through completion of this Stage 3 document have been greatly appreciated.

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Vermilion Port Authority
Linwood Park Cottage Owners Association, Inc., Vermilion, OH
Tetra Tech, Inc., Alexandria, VA
Stanley Consultants, Cleveland, OH

The Buffalo District has conducted this investigation under the general supervision of Donald M. Liddell, Chief, Engineering Division, Charles E. Gilbert, Chief, Planning Division, and John Zorich, Chief, Western Branch. Colonel George P. Johnson was the District Engineer during preparation of this Stage 3 Detailed Project Report.

We further extend our acknowledgment to all those who in some respect have contributed to the achievement of this document.

SECTION I

INTRODUCTION

Vermilion Harbor is located on the south shore of Lake Erie, at the mouth of the Vermilion River, approximately 37 miles west of Cleveland, OH (See Figure 1.1). It is presently a small-craft harbor originally constructed in 1836 by the Federal Government for commercial purposes, under the authority of the Rivers and Harbors Act of 1836. The navigation channels were later improved by the Rivers and Harbors Act of 1875, and modified in 1878 to include two parallel piers at the river mouth. The latest Federal improvements to the harbor were completed in December 1973, and consisted of widening and deepening, and construction of a cellular steel sheet pile detached breakwater located approximately 300 feet offshore from the end of the parallel piers. During and subsequent to this latest construction, there have been repeated complaints from local residents and other interested groups, that the detached breakwater has caused adverse impacts to the adjacent shoreline and the community as a whole. Mr. William B. Nye, former Director of the Ohio Department of Natural Resources, officially requested in 1975 that the Corps investigate the severity of the erosion problem allegedly created by the breakwater.

As a result of these expressed concerns, the Corps of Engineers initiated in 1975 an investigation of the need for mitigation of shoreline damages, attributable to the navigation works at Vermilion Harbor, OH, under the authority of Section 111 of the Rivers and Harbors Act of 1968 (PL 90-483). In January 1976, the Buffalo District completed a Section 111 Reconnaissance Report recommending that no action be taken to prevent or mitigate shore damages, and a 5-year monitoring program be undertaken prior to initiation of further detailed studies. Subsequent to completion of the Preliminary Report, further evaluation of that program led to the conclusion that it would only identify short-term shoreline changes; and because of very little baseline data (pre-breakwater construction data) any conclusions drawn from observations would not be highly reliable. The 5-year monitoring program was therefore terminated.

During Stage 2 investigations, it was concluded that the Federally constructed breakwater at Vermilion Harbor had caused a reorientation of the shoreline east of the harbor. As a result, several alternative plans were developed, studied, and evaluated with a view to mitigating the shore damages. Several workshops, public meetings, and telephone and written communications were accomplished to discuss both the issues concerning the impacts of the breakwater on the shoreline processes, and the alternative solutions which were being considered. The Stage 2 report recommended carrying forth into Stage 3, the most economically feasible plans which would satisfy both Federal and local interests. In reviewing this Stage 2 report, the North Central Division identified the need to study mitigation of shoreline damages to the west of the harbor structures. In 1979, a mitigation

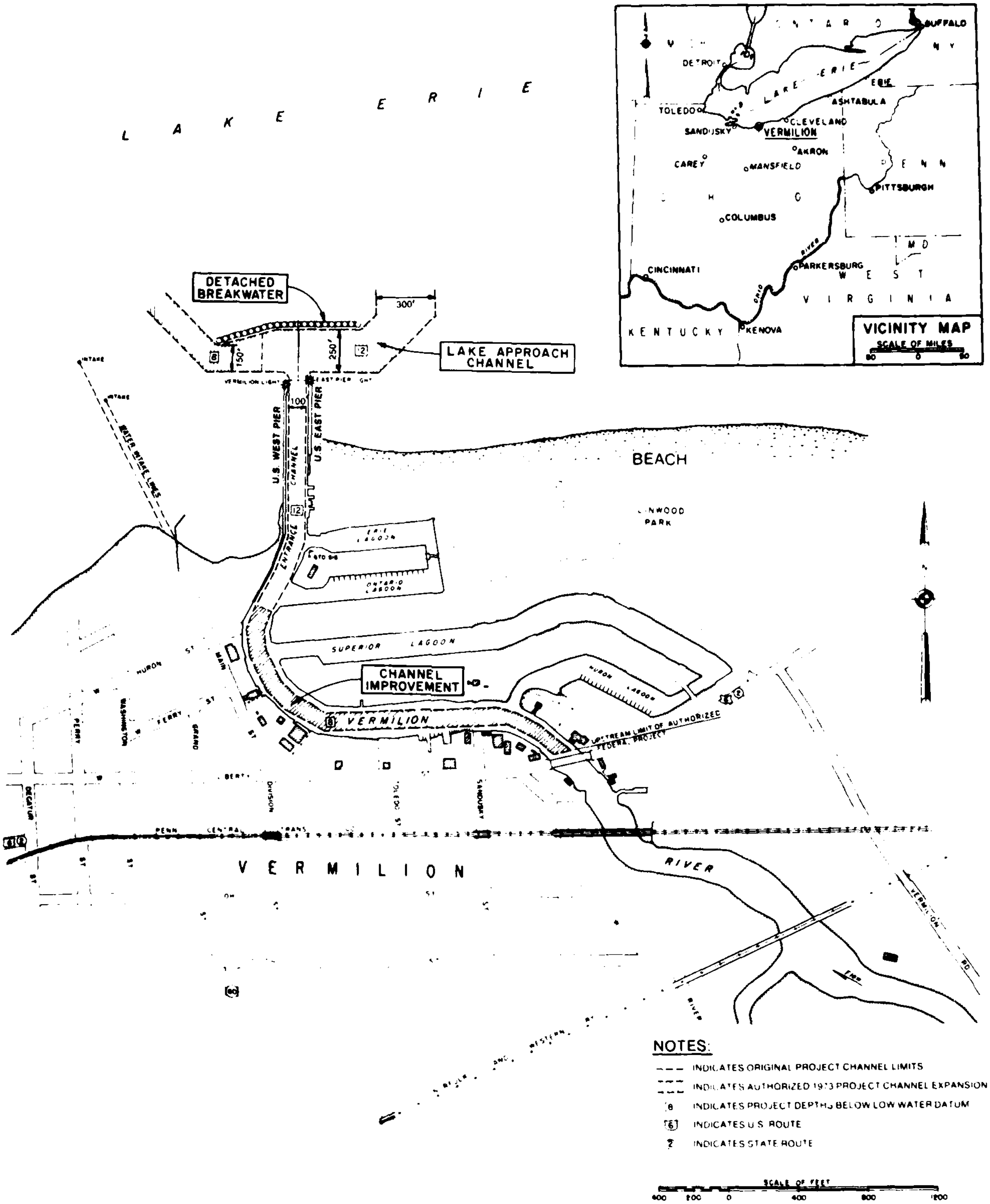


Figure 1.1 • VERMILION HARBOR LAYOUT & LOCATION

study was performed to determine the extent of shoreline damage to the west of the harbor attributable to the breakwater.

This final report documents the Stage 3 investigations of the shoreline processes to the west and east of harbor structures. It outlines the alternative plans developed, and presents the conclusions and recommendations reached as to mitigating alleged shore damages attributed to the Federal Navigation works at Vermilion.

Study Authority

This report was prepared under the authority of Section 111 of the Rivers and Harbors Act of 1968, PL 90-483, approved 13 August 1968, which states:

> "The Secretary of the Army, acting through the Chief of Engineers is authorized to investigate, study, and construct projects for the prevention or mitigation of shore damages attributable to Federal navigation works. The cost of installing, operation and maintenance shall be borne entirely by the United States. No such projects shall be constructed without specific authorization by Congress if the estimated first cost exceeds $1,000,000."

Study Purpose

The purpose of this investigation is to determine whether the Federal navigation improvements at Vermilion Harbor have caused, or substantially increased the erosion of the shore or beaches east and west of the harbor, and if so, determine what measures are justified to mitigate the damages.

Study of Other Possible Breakwater Impacts

As noted previously, soon after construction of the detached breakwater in 1973, the Buffalo District began receiving complaints that the breakwater was causing a number of adverse impacts in the community. In addition to the shoreline erosion problem addressed in this Section 111 report, the other potential impacts of concern to local interests are the effect of the breakwater on municipal water supply; swimming areas and beaches; ice-jam flooding; free-flow flooding; sedimentation; navigation; and aesthetics. The results of the study of these potential impacts are presented in a companion report titled Vermilion Harbor, Ohio, Study of the Impact of the Offshore Breakwater on: Municipal Water Supply; Swimming Areas and Beaches; Ice Jam Flooding; Free-Flow Flooding; Sedimentation; Navigation; and Aesthetics, dated November 1981.

The Study Process

The Vermilion Section 111 study is a three-stage study carried out under Section 111 of the continuing authority program (Project not Specifically Authorized by Congress) which authorizes the investigation, study and construction of projects to mitigate shore damages attributable to Federal navigation works. The first stage of this study scoped general investigation activities and the direction of the study. It produced, in January 1976 a

"Reconnaissance Report" which recommended that no action be taken under Section 111 to prevent or mitigate shore damages in the vicinity of the Vermilion Harbor. It also recommended that a monitoring program be accomplished over a 5-year period (1976-1980), to be followed by a supplemental Section 111 study based on the results of that monitoring program. However, late in 1976, the District reevaluated its position regarding the 5-year monitoring program, which because of the limited baseline data available would only identify short-term shoreline changes and lead to unreliable conclusions. By letter dated 12 November 1976 to North Central Division (Appendix D), the District requested and received approval to proceed with the Detailed Project Report. The second stage of this study, performed by Stanley Consultants in May 1978, was to determine the extent of shore damages, if any, due to the Federal Navigation works at Vermilion Harbor. (It should be noted that the study dealt primarily with evaluating the effect of the detached breakwater on the shoreline to the east of the harbor.) As a result, a range of alternative solutions to the erosion and environmental, health, flooding, and recreational problems were identified and analyzed. The District prepared preliminary designs, cost estimates, and benefit calculations for the alternatives considered to restore the easterly beaches to their estimated prebreakwater condition. From this Stage 2 analysis presented in the Syllabus to Stanley Consultants' May 1978 Section 111 report, the District concluded that mitigation of the loss of beach at Linwood should be undertaken. The investigations concerning the environmental, health, flooding, and recreational problems were presented in a separate report dated April 1978 and titled "Vermilion Harbor, OH, Study of the Offshore Breakwater on: Municipal Water Supply, Swimming Areas and Beaches, Ice-Jam Flooding, Sedimentation, Navigation, and Aesthetics."

In reviewing the District's Stage 2 Section 111 report in mid-1978, the North Central Division noted the need to study mitigation of shoreline damages to the west of the harbor structures. In the summer of 1979, the District contracted with Tetra Tech, Inc. to perform that study. The objectives of that study were to determine the amount of shoreline damages to the west of the harbor attributable to the navigation structures, prepare preliminary designs and cost estimates for a range of alternative plans to mitigate any damages, and recommend the appropriate plan of action if such plan is economically justified. Tetra Tech's July 1980 report on that study is included as Appendix B to this Stage 3 Draft DPR. Tetra Tech made an analysis of historical data in the form of available maps, field surveys, and aerial photographs to determine the effect of the harbor structures on the shoreline to the west. As a result of the analysis, it was found that 8,100 feet of shoreline to the west are influenced by the harbor structures. To evaluate the shoreline damages, Tetra Tech considered shoreline positions for three conditions of harbor development:

Condition 1 - No Federal Harbor structures

Condition 2 - Federal Project with Harbor Piers only

Condition 3 - Existing Federal Project (Piers and Breakwaters)

Preliminary designs and cost estimates were prepared for four alternative plans to mitigate shoreline damages to the west of the harbor.

The Tetra Tech's final report published in July 1980, recommended that no action be taken to mitigate shore erosion to the west that has been induced by the Federal harbor structures at Vermilion. It emphasized that, due to early shore protection measures constructed by private land owners in Vermilion, much of the shoreline along the study reach is relatively well-fortified and, therefore, resistant to erosion-induced damage.

The District concurred in Tetra Tech's recommendation. Its (the District) evaluation of the Tetra Tech's report concludes that the methodologies used, and the conclusions reached regarding shoreline erosion rates and shoreline damages to the west for both the pre- and post-harbor project conditions are reasonable. Therefore, no mitigation of shoreline damages to the west of the harbor should be undertaken.

As part of the Stage 3 studies, the District performed in May 1979 a Sand Pumping Demonstration Program to determine the practicability of pumping sand from the East fillet to Linwood Beach, using a small floating hydraulic dredge. The program was considered unsuccessful for a number of reasons such as insufficient pump capacity for the size of sand (significant amount of gravel) being pumped to Linwood Beach, the long pumping distance involved, and so on. Subsequent to the Sand Pumping Demonstration Program, further observations of the easterly beaches and qualitative interpretations of the coastal processes in the area do not uphold the Stage 2 conclusion that mitigation of shoreline damage to the east of the harbor is warranted. Therefore, in September 1980, a Stage 3 investigation was undertaken to identify present as well as historical changes in the shoreline east of Vermilion Harbor.

This third and final stage of the investigation was performed by Tetra Tech. It develops, refines, and updates studies to the extent necessary to reconsider the need for mitigation at the Lagoons, Linwood, and Nakomis Beach reaches east of the harbor. The Buffalo District has scoped this study to identify the pros and cons and public preferences regarding conclusions and recommendations affecting the Vermilion Beach complex, and to determine whether or not these recommendations can be implemented.

This Stage 3 Final Detailed Project Report includes a main report and four appendices. The main report is written to give both the general and technical reader and the reviewing echelon a clear understanding of the study, the study results, and the basis for key decisions, conclusions and recommendations. It documents the logic of the planning process and its conclusions in accordance with the requirements of the Engineering Regulation ER-1105-2-200 series. The length and level of detail is considered sufficient to fully support the essential analyses and conclusions and recommendations of the study. Its organization and content follows the Corps of Engineers guidelines for feasibility reports as defined by ER 1105-2-920. The appendices provide detailed technical evaluation of shoreline changes east and west of the harbor through analysis of the shores and beaches characteristics, littoral sediments, and the physical forces involved such as waves, winds, currents, lake water levels. . . They also provide detailed economic evaluation of the alternative mitigation plans developed, and a basis for the District's conclusions on the investigation, and recommendations regarding mitigative action(s) to be taken.

Study Participants and Coordination

The Buffalo District has conducted this study as a result of a request by Mr. William B. Nye, former Director of the State of Ohio Department of Natural Resources. In October 1975, the District Engineer met with Mr. George W. Grossman, a resident of the Linwood Park Community, in order to explain the Buffalo District's Section 111 study of the shoreline changes that have been attributed to the Federal navigation project. Other meetings whose purpose was to coordinate activities were also held at various times. In answer to public concerns regarding the effects of the detached breakwater at Vermilion Harbor, the District, on 30 August 1977, held a public meeting whose primary purposes were to inform all parties concerned of the Corps actions to evaluate the impacts of the detached breakwater, and to receive input from the public as to any changes that had occurred since the breakwater construction in 1973. Another public meeting was held on 31 August 1978 to discuss the results of the initial phase of the investigation of the effects of the detached breakwater on Vermilion Harbor and surrounding areas, and solicit public views on the future course of action to follow. A public hearing was held on 10 April 1979 at the Vermilion Town Hall to gather information and data relevant to the disposition of approximately 15,000 cubic yards of sand at Linwood Beach after it (sand) has been hydraulically dredged and pumped from the Lagoons Beach area. Comments received by the District Engineer during public review of the draft reports published in March 1982, indicated that many of the respondees particularly those of in Linwood Park, misunderstood the study results with respect to ice-jam flooding and shore erosion. As a result, the District, on 23 June 1982, held a public information meeting to clarify these aspects of the study. (For detailed information on public meetings see Appendix D.)

The Buffalo District has coordinated with several Federal, State, county, and regional agencies including:

Federal

U.S. Fish and Wildlife Service
Conrad Fjetland, Supervisor
3990 East Broad Street
Columbus, OH 43215

U.S. Coast Guard (USCG)
9th Coast Guard District
Cleveland, OH

State

Ohio Department of Natural Resources
Bruce McPherson, Coastal Zone Management Coordinator (CZM)
Fountain Square
Columbus, OH 43215

Regional

Vermilion Port Authority
Mr. Richard Bulan
c/o Town Hall
Vermilion, OH 44089

Mayor, City of Vermilion
P.O. Box 317
Vermilion, OH 44089

Coordination with these agencies was to discuss related information they had on the study area and to insure that they were kept abreast of study developments so that they could evaluate and provide valuable input to the various alternatives considered.

The Buffalo District has maintained coordination with U.S. Coast Guard (USCG) to obtain their views on problems with ice breaking operations at Vermilion and modifications to Vermilion Harbor that were required to permit reliable and safe ice breaking operations in the harbor. Coordination was also maintained with local officials including the Mayor, City of Vermilion, the City Engineer, and local citizens knowledgeable in ice breaking operations in the river and harbor.

The District has cooperated with citizen interest groups, including the Vermilion Lagoons Association and the Linwood Park Company which own the Lagoons and Linwood Beaches, and the Equal Beach Restoration Association (EBRA). EBRA is an organized group of local citizens, residing west of the Vermilion Harbor, interested in mitigation of shoreline damages in their area. They have provided some information on shoreline changes to the shore to the west of the harbor structures.

The Report

This main report is divided into seven sections which are identified by appropriate titles with related subtitles and paragraphs providing general information pertinent to the study. These sections are followed by four appendices which provide detailed technical, environmental and other background information on the subjects discussed in the main report. A brief description of the main report follows:

Section I - is an introductory section which briefly describes the events leading to this report. It discusses the study authority, purpose and process; and identifies the study participants.

Section II - describes the general characteristic traits of the study area (its river, artificial lagoons, beaches, bluffs, etc.). It discusses its natural environment, climate, soils and geology, sediment, fisheries, water quality, human environment (land, water uses, recreation), cultural opportunities, economy, resources, population and other demographic information.

Section III - identifies problems, needs, and concerns about the Federal harbor navigation structure. It provides a brief discussion on the disposal of the harbor dredge materials and the ongoing investigation on the feasibility of near-shore dumping. It also defines the national objectives and general and specific planning objectives.

Section IV - summarizes those studies pertaining to the Vermilion Harbor: The shoreline erosion mitigation studies, and other related erosion studies and activities.

Section V - discusses the study of shoreline damages to the west of the harbor; provides a brief description of the mitigation plans developed, and a summary evaluation for mitigation of those damages. It also discusses the need to mitigate breakwater-induced shoreline damages to the east of the Vermilion Harbor. It highlights some important conclusions of the Tetra Tech 1981 investigation of shore erosion to the east (beach area changes, shoreline changes, and bluff changes). It reports analysis of the conditions of the study area for the periods 1948-1973 (prebreakwater conditions), and 1973-1980 (postbreakwater conditions). It also provides a summary analysis and evaluation of the impacts of the breakwater on the shore condition.

Section VI - provides an overview of the conclusions reached by Stanley Consultants and Tetra Tech in their technical reports of the shoreline erosion investigation to the east and west of harbor. It also contains conclusions reached by the Buffalo District.

Section VII - contains recommendations on the need for mitigative action as a result of this Stage 3 investigation.

Section VIII - discusses future activities and proposed schedule.

The four appendices are as follows:

Appendix A - Detailed Technical Evaluation of Shore Changes East of the Harbor (Tetra Tech, 1981 Report).

Appendix B - Detailed Technical Evaluation of Shore Changes West of the Harbor (Tetra Tech, 1980 Report).

Appendix C - Other pertinent studies such as:

Stanley's 1978 Technical Report
Sand Pumping Demonstration Program
Section 14 Report (Interceptor Sewer)
Operation and Maintenance (Statement of Findings)

Appendix D - Public Involvement.

SECTION II

THE STUDY AREA

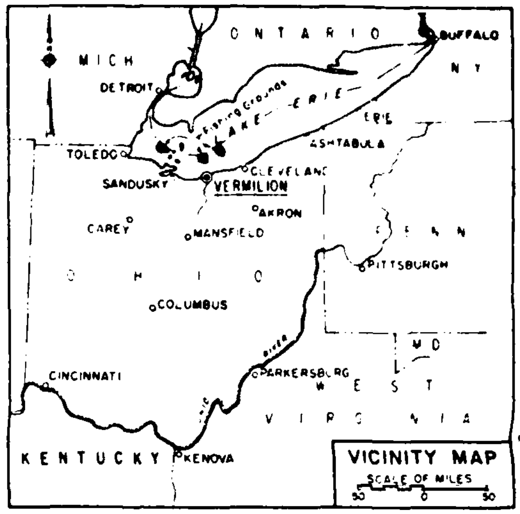
Existing Conditions

Vermilion Harbor is a Federally constructed commercial harbor also used for recreational and commercial fishing craft. It is located in Erie County, OH, on the south shore of Lake Erie at the mouth of the Vermilion River, about 37 miles by water, westerly of Cleveland, OH, and 21 miles easterly of Sandusky, OH. Lorain and Huron Harbors, 11 miles east and west of Vermilion respectively, are the nearest Federally improved harbors (see Plate 2.1).

Vermilion Harbor is comprised of a channel of approach from the lake, and the lower 3,600 feet of Vermilion River. The river rises in the Savannah Lakes in the northern part of Ashland County, OH, and follows a generally northerly course for 45 miles to Lake Erie (see locality map; Plate 2.1). The drainage area of the watershed is about 272 square miles. For about 2 miles above the mouth, the river is generally straight with the exception of an elongated "S" curve between the mouth and Liberty Street Bridge. From its mouth to the upstream limits of the Federal Project at Liberty Street, the river varies in width from 80 to 100 feet, having depth in pools ranging up to 12 feet. Immediately east of the Vermilion River, and south of Lake Erie lie a series of man-made lagoons. The area was a marshland before construction of these lagoons. From north to south, they are Erie, Ontario, Superior, and Huron. Bordering these lagoons are about 150 year-round single-family residences of Cape Cod architecture which form the Vermilion Lagoons Association. About 149 single-family cottages form the Linwood Park Company located immediately east of the lagoons area. Lagoons and Linwood Beaches are owned by the Vermilion Lagoons Association and the Linwood Park Company, respectively. The several lagoons which had been constructed by private interest groups on the east side of the river have depths averaging about 4 feet.

The particular area of interest to the study consists of that reach of Lake Erie shoreline, extending approximately 4,000 feet east of the harbor to Crystal Shores and about 8,100 feet west to Coen Road. The shoreline immediately to the east of the harbor structures is characterized by an exposed sand beach, about 3,000-feet long, and varying in width from approximately 500 feet at the East Pier fillet through a summer resort area known as Linwood Park to near zero foot at the easterly limit of Nakomis Beach (see Plate 2.2). The beach area ends at the base of a steep Huron formation shale bluff approximately 10 to 15 feet high. The shale outcrop extends for about 2-1/2 miles to the east, where it dips below lake level, remaining submerged until it rises above water level about 1 mile east of Lorain.

West of the West Pier lies Vermilion City Beach which is about 50 to 75-feet wide and extends 600 feet to the west. A bluff consisting of boulder clay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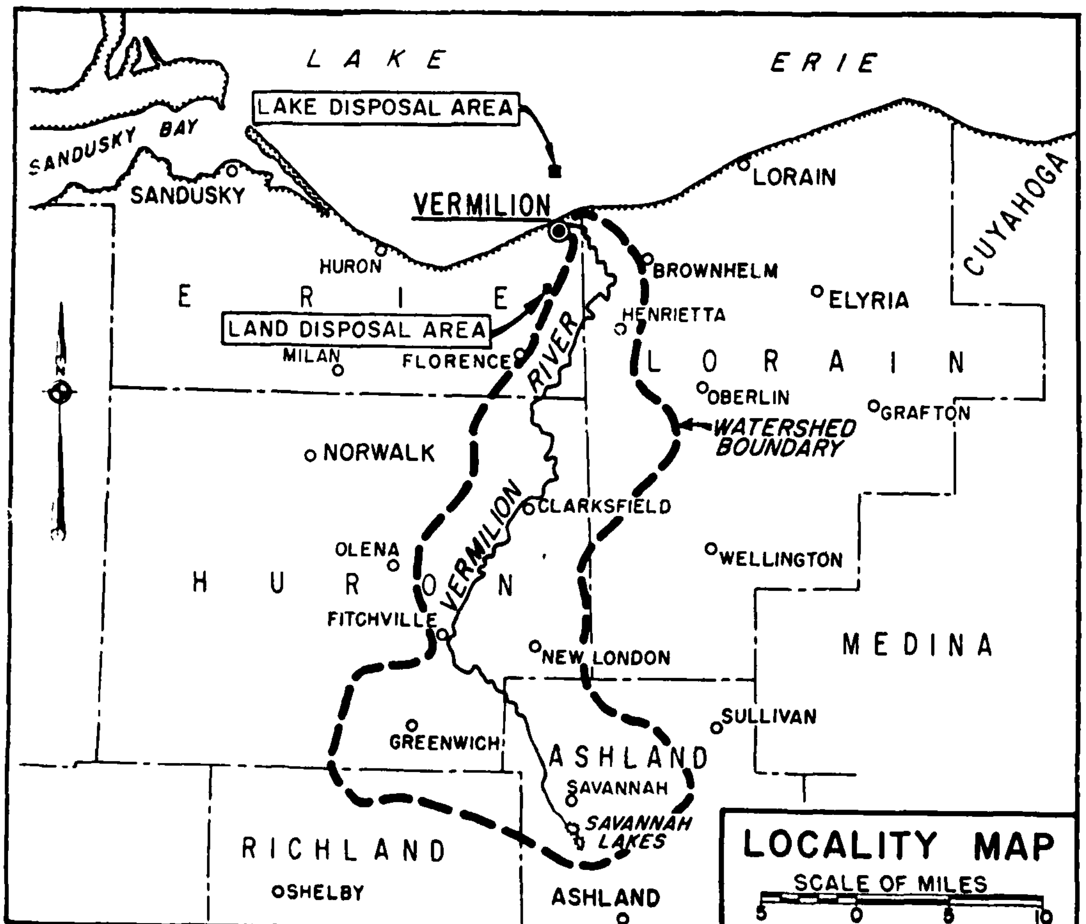
SCALE OF MILES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FLORENCE
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PLATE 2.1

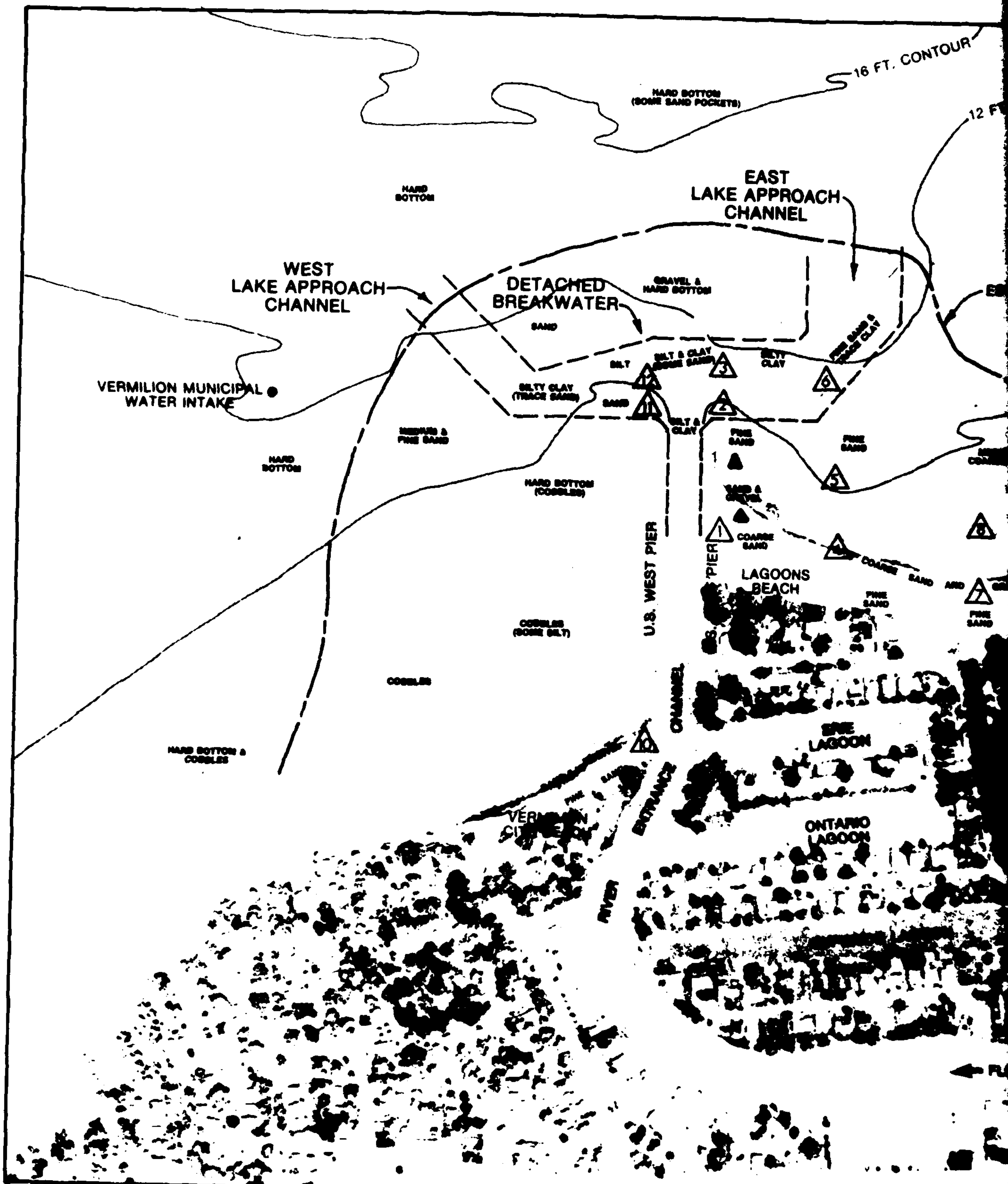
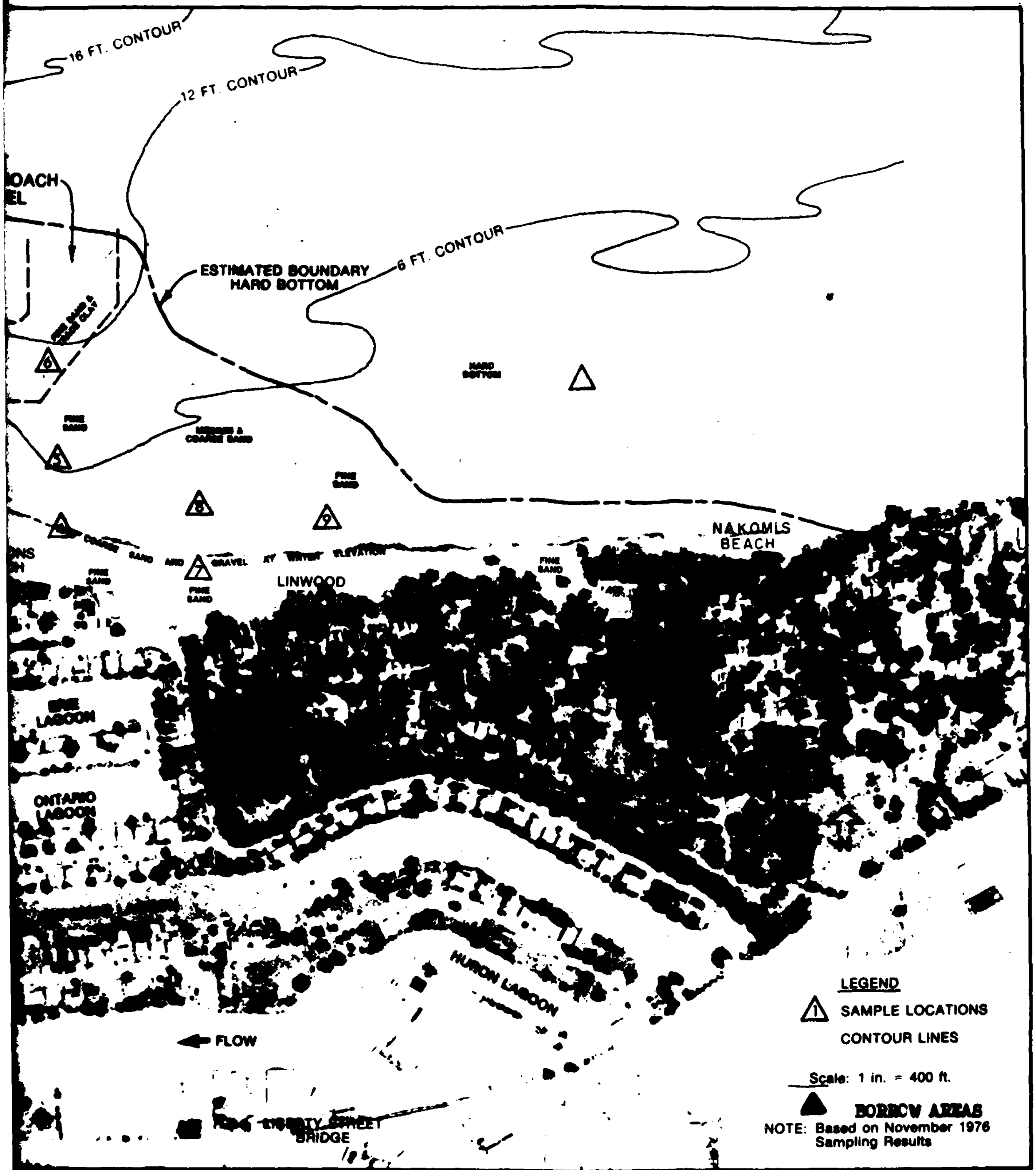


PLATE 2.2 DISTRIBUTION OF BE



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overlain with lacustrine deposits rises up to 10 feet above low water datum, and gradually increases to the west, reaching 30 feet, about 4 miles from Vermilion. To the west of the City Beach, the shoreline is almost completely developed with residences. Numerous short groins or stone-filled timber cribs have been built to trap protective beaches.

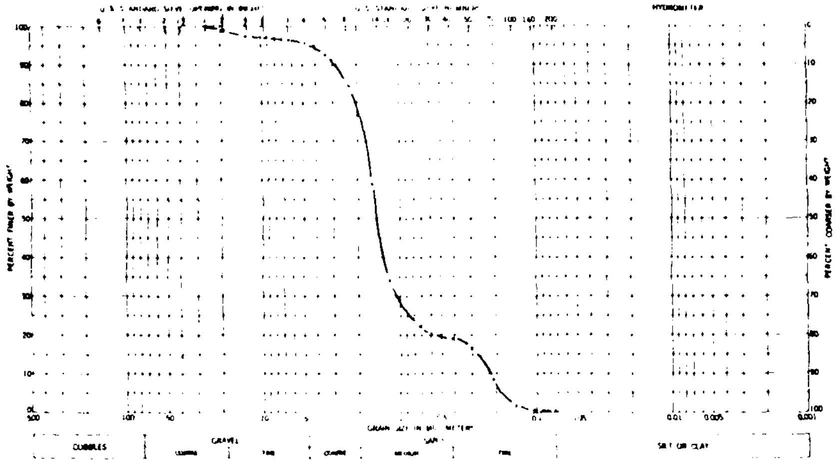
Beach materials generally vary from fine to medium sand with some gravel and cobbles prevalent near the water line. Figures 2.1 through 2.4 show beach material gradation curves for selected locations in the study area. Grain size analysis of the bluff materials indicates that only 12 percent of the material is fine sand or coarser and suitable for natural beach building. A much larger percentage of sand makes up the composition of the bluff at Linwood Beach. Where the shale surface is submerged, the coastline is primarily boulder clay overlain with sand deposits, with a few small sand pockets.

The nearshore lake bottom immediately west of the harbor is hard shale with some cobbles, boulders, and occasional traces of sand. For more information on the geology of the area, refer to: (a) House Document No. 32, 83rd Congress, 1st Session, Appendix VI, Ohio Shoreline of Lake Erie, Sandusky to Vermilion, Ohio, Beach Erosion Control Study, 5 December 1952; (b) House Document No. 229, 83rd Congress, 1st Session, Appendix VIII, Ohio Shoreline of Lake Erie Between Vermilion and Sheffield Lake Village, Beach Erosion Control Study, 3 August 1953.

Water surface elevations on the Great Lakes vary irregularly from year to year. The maximum fluctuation between the average annual high and low, still water levels for Lake Erie was 4.7 feet. These water level fluctuations, uncharacteristic of ocean shores are due to variations in climatic factors within regional drainage basins. In the Vermilion area, still water level variations are as indicated in Table 2.1.

These fluctuations are produced by rainfall and runoff in the Great Lakes Basin, and are unpredictable except within 4 to 6 months in advance of occurrence. Levels also vary on a seasonal basis, with the summer high levels averaging about 1.5 feet above the winter low levels. Figure 2.5 provides pertinent data on monthly average Lake Erie levels for the period 1950 through June 1980. Short-term fluctuations in levels, produced by winds and barometric pressure differentials are quite pronounced on Lake Erie because its shallow depth (60 feet average) provides less opportunity for the wind-impelled surface water to return through reverse currents beneath the surface. Based on water level gage data obtained from the Toledo and Cleveland stations, short-term fluctuations (wind setup) of about 1.8 feet and 2.3 feet can be expected at Vermilion annually, and every 5 years, respectively. In addition to annual and seasonal fluctuations, storms produce water level changes due to barometric pressure changes or prolonged strong winds whose stresses on the water surface cause a vertical rise or setup in the still water level on the leeward side of the body of water. At Vermilion, this effect can result in water level changes of the magnitude described above.

The dominant forces involved in shoreline erosion are winds and waves. The winds, also known as wave generators, act directly upon beaches by creating



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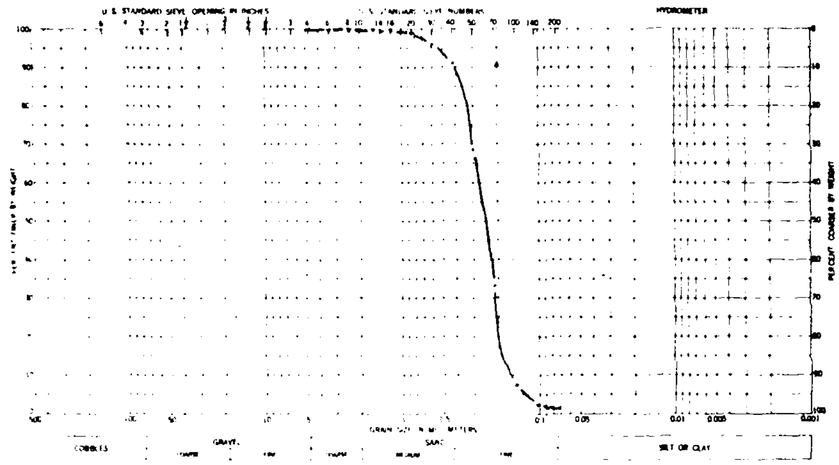

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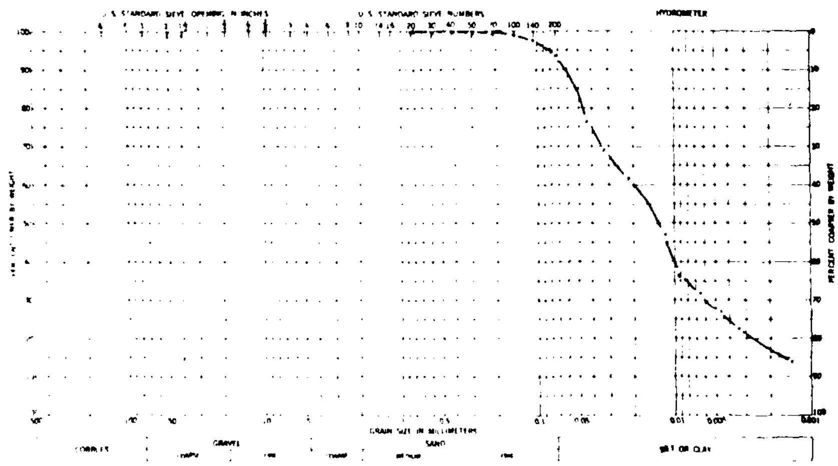

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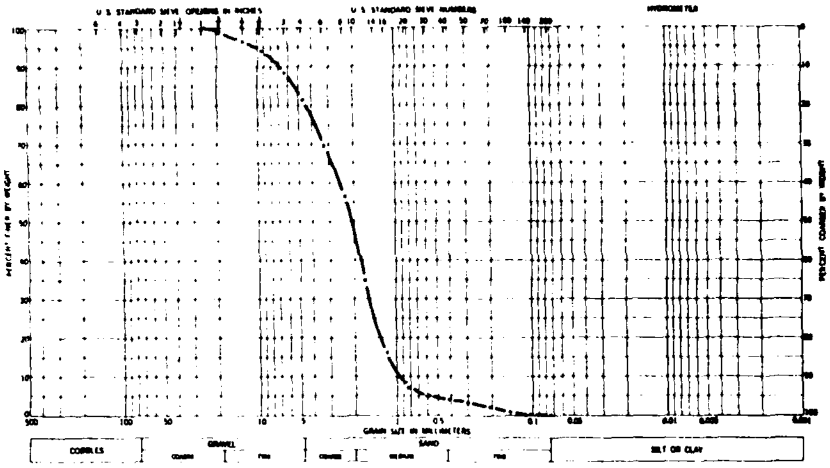
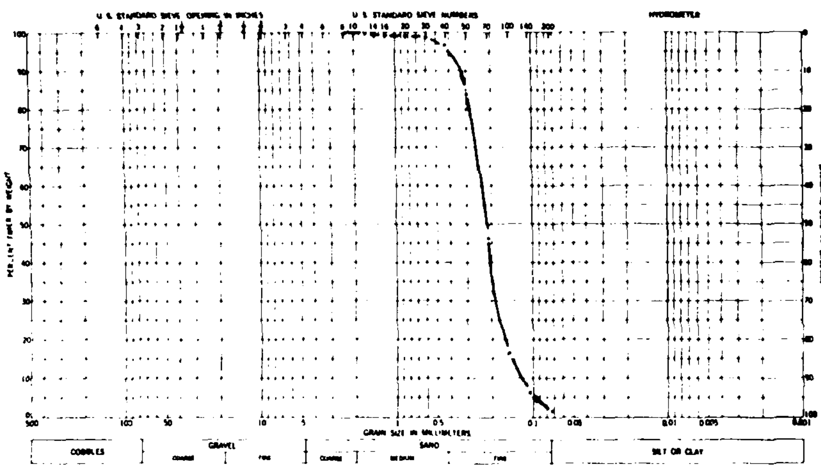
NOTE Sample locations shown on Plate 2.2

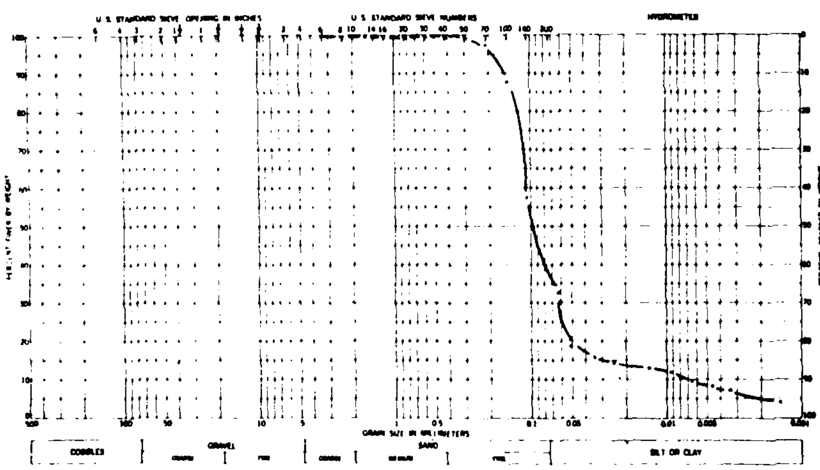
Figure 2.1 • SEDIMENT GRADING CURVES - STATION 0+00 E



SAMPLE NUMBER: 4
STATION POINT: 4+00 E
DATE: 11/16/76



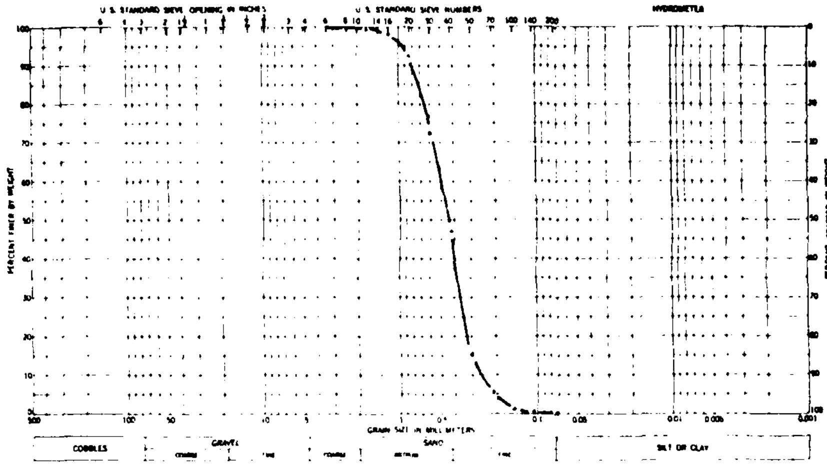
SAMPLE NUMBER: 5
STATION POINT: 4+00 E
DATE: 11/19/76



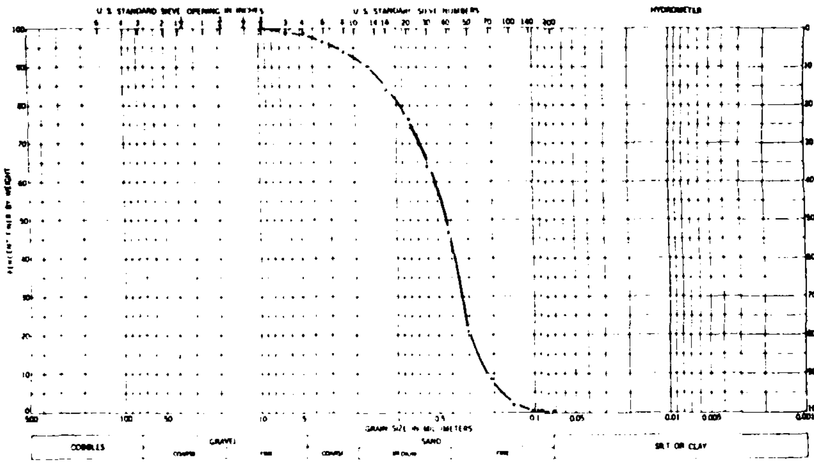
SAMPLE NUMBER: 6
STATION POINT: 4+00 E
DATE: 11/15/76

NOTE: Sample locations shown on Plate 2.2

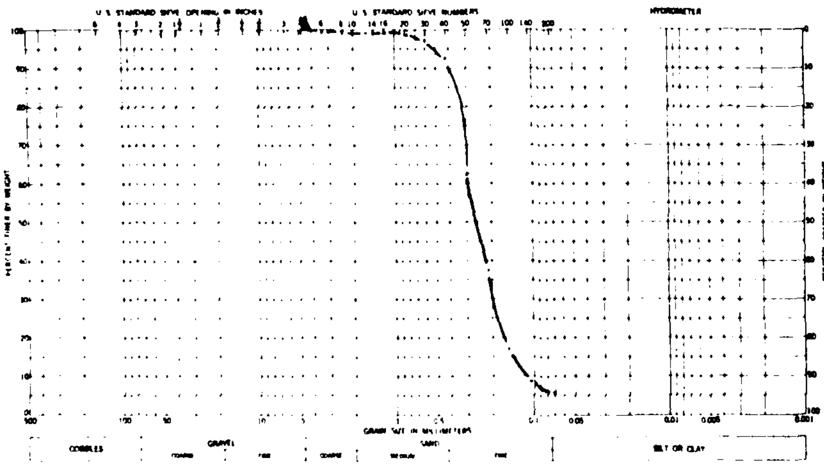
Figure 2.2 • SEDIMENT GRADING CURVES - STATION 4+00 E



SAMPLE NUMBER: 7
STATION POINT: 8+00 E
DATE: 11/11/76



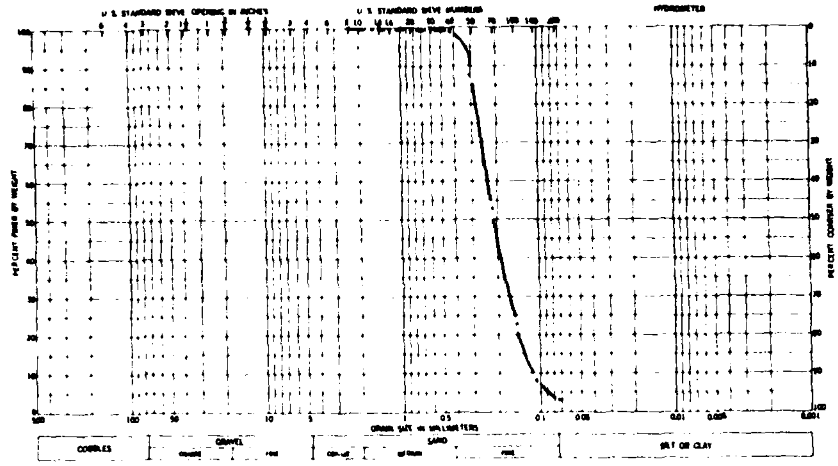
SAMPLE NUMBER: 8
STATION POINT: 8+00 E
DATE: 11/30/76



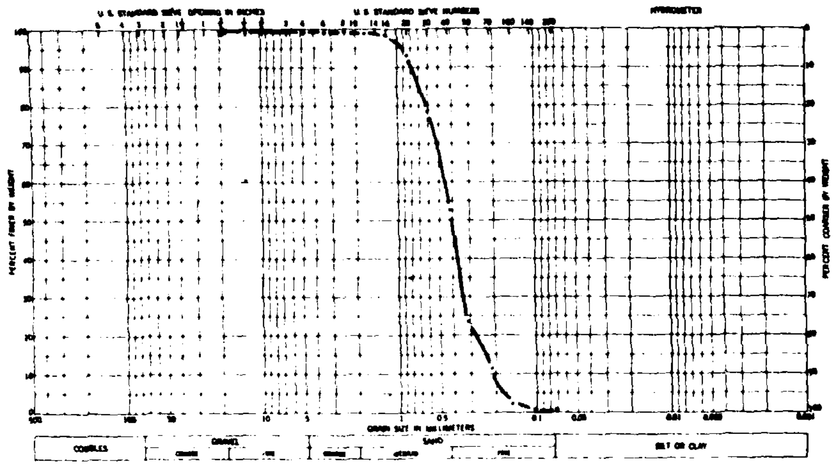
SAMPLE NUMBER: 9
STATION POINT: 12+00 E
DATE: 11/26/76

NOTE: Sample locations shown on Plate 2.2

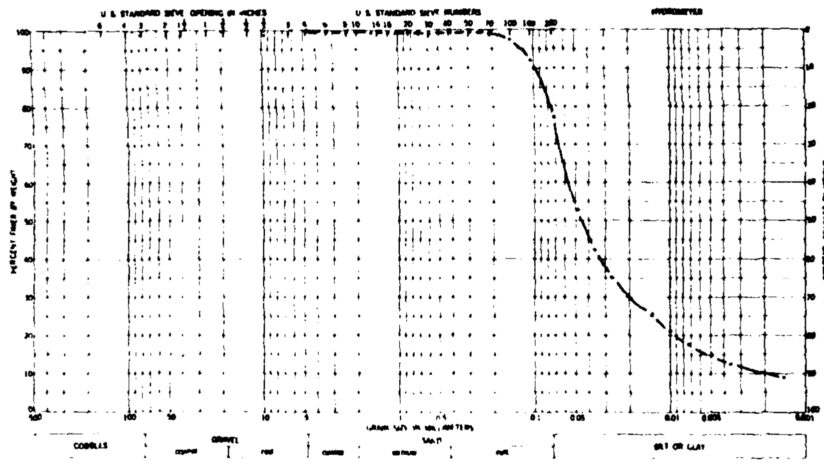
Figure 2.3 • SEDIMENT GRADING CURVES - STATION 8+00 E AND 12+00 E



SAMPLE NUMBER: 10
STATION POINT: 2+00 W
DATE: 11/23/76



SAMPLE NUMBER: 11
STATION POINT: 2+00 W
DATE: 11/10/76



SAMPLE NUMBER: 12
STATION POINT: 2+00 W
DATE: 11/18/76

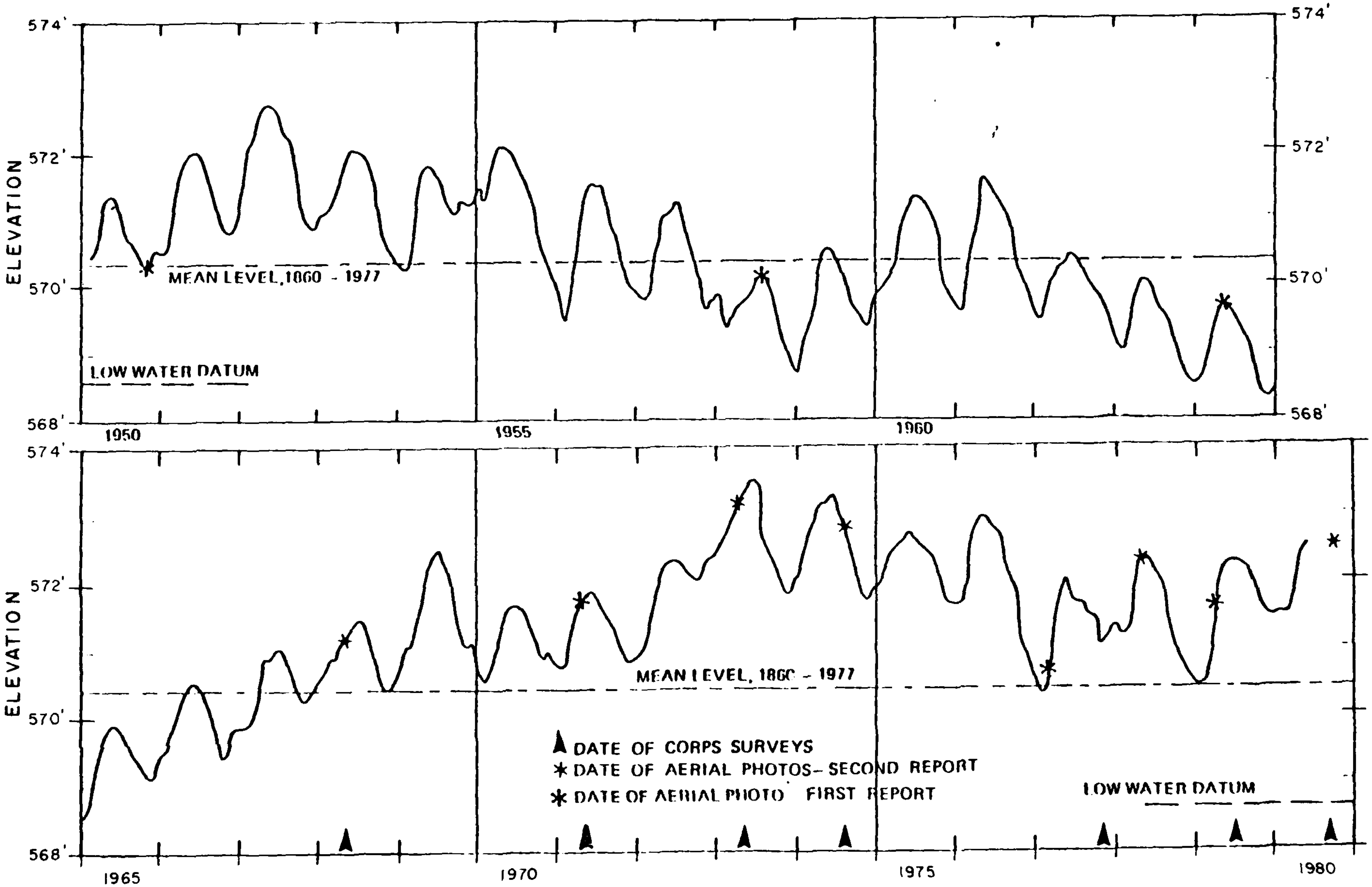
NOTE: Sample locations shown on Plate 2.2

Figure 2.4 • SEDIMENT GRADING CURVES - STATION 2+00 W

Table 2.1 - Lake Erie Water Levels, 1860-1974

Item	Elevation IGLD (1)	Elevation LWD (1)	Date
Highest Monthly Mean Stage	573.51	4.91	June 1973
Lowest Monthly Mean Stage	567.49	-1.11	February 1936
Long-Term Mean Surface (1860-1967)	570.36	+1.76	
Yearly Mean 1968	570.92	+2.32	
Yearly Mean 1969	571.54	+2.94	
Yearly Mean 1970	571.10	+2.50	
Yearly Mean 1971	571.27	+2.67	
Yearly Mean 1972	571.89	+3.29	
Yearly Mean 1973	572.71	+4.11	
Yearly Mean 1974	572.52	+3.92	
Yearly Mean 1975	572.27	+3.67	
Yearly Mean 1976	572.10	+3.50	
Yearly Mean 1977	571.24	+2.64	
Yearly Mean 1978	571.48	+2.88	
Yearly Mean 1979	571.55	+2.95	

(1) Elevations are referenced to mean water level at Fathers Point, St. Lawrence River, Quebec, and are on International Great Lakes Datum - 1955 (IGLD-1955). Low Water Datum (LWD) for Lake Erie is elevation 568.6 (IGLD-1955).



NOTE:
ELEVATIONS RELATIVE TO FEET ABOVE MEAN WATER LEVEL AT FATHER POINT, QUEBEC (IGLD, 1955)

HYDROGRAPH OF MONTHLY MEAN LEVEL OF LAKE ERIE (1950-1980)

FIGURE 2.5

shear forces upon the individual sand particles and thereby blowing sand off the beach or depositing sand in dunes. In the Vermilion area, predominant winds are from the southwest. Those from the west-northwest to east vary widely in intensity, that is, from light summer breezes of 5 to 10 miles per hour (mph) to severe storms in excess of 60 mph (see Figure 2.6). The largest wind transport losses are usually associated with accreting beaches that provide a broad area of loose sand. Such a circumstance has occurred at Lagoons Beach where sand overtopping the east pier necessitated maintenance dredging at the Entrance Channel. Wind transport is not of any significance at Vermilion, however.

Wave climate on Lake Erie is often violent, causing rapid shore erosion as well as strong long shore currents. At Vermilion, the larger, steeper waves created by strong northeast and northwest winds are the most effective waves in eroding and transporting sediment materials. The predominant directon of littoral drift in the study area is from east to west, although reversals do occur. Since wind and wave data are not available for Vermilion, historic wind data at Lorain Harbor was used for design purposes. Their characteristics are given in Table 2.2.

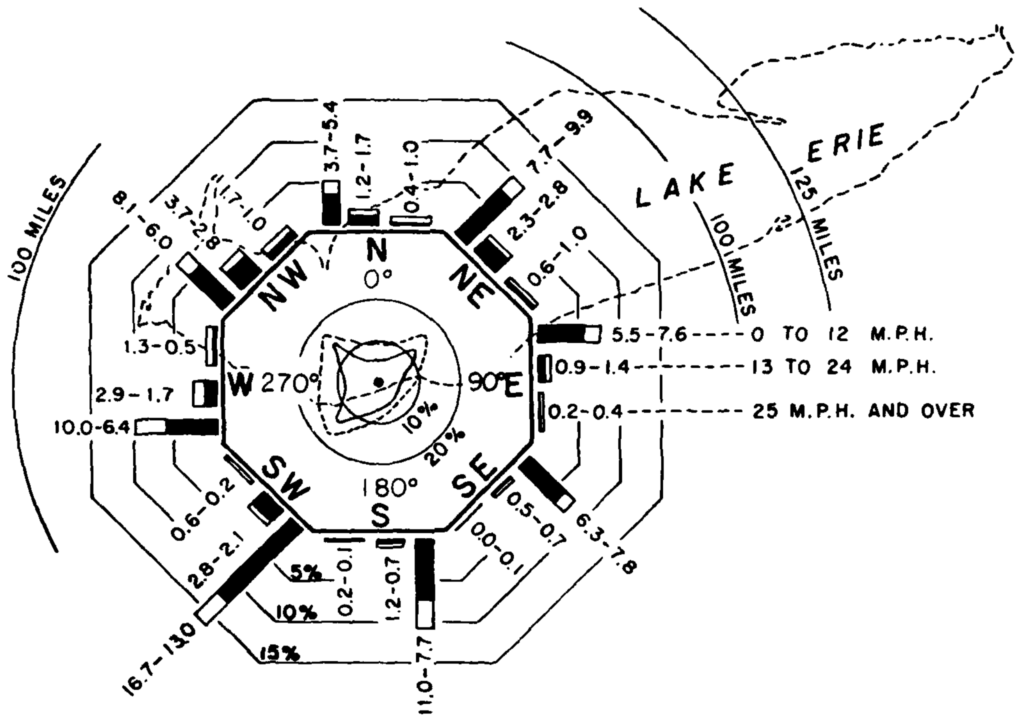
Table 2.2 - Wind and Deepwater Wave Characteristics

Fetch		Wind		Waves	
Direction	Length (miles)	Velocity (mph)	Duration (hours)	Height (feet)	Period (seconds)
West	20	50	20	9.0	6.5
Northwest	50	42	12	9.0	7.5
North	50	35	12	8.5	7.0
Northeast	100+	35	24	11.0	8.0

SOURCE: General Design Memorandum, Vermilion Harbor, Ohio, Buffalo District, August 1971.

Water quality at Lagoons and Linwood Beaches are monitored weekly during the bathing season by the Erie County Health Department. Beaches are required to be posted as unsafe if fecal coliform data exceed 200/100 ml (200 colonies per 100 ml) for three consecutive weeks. Lagoons Beach data are available since 1974, during which the beach has never been posted as unsafe. Linwood Beach was first monitored in 1978 when unsafe posting was not required. Based on available information, there is little indication that any major long-term changes in pollution sources in the Vermilion River Basin have occurred since the breakwater construction. Fecal coliform data is generally quite high (200-1,000 colonies per 100 ml) and highly variable with no trends discernible.

No specific data are presently available on fisheries for the beach area concerned. However, a survey conducted in 1975 by a "Corps Contractor"



WIND DIAGRAM FOR LORAIN HARBOR, OHIO

NOTES

- INDICATES DURATION FOR ICE-FREE PERIOD (MAR. TO DEC. INCL.) IN PERCENT OF TOTAL DURATION.
- INDICATES DURATION FOR ICE PERIOD (JAN. TO FEB. INCL.) IN PERCENT OF TOTAL DURATION.
- INDICATES PERCENT OF TOTAL WIND MOVEMENT OCCURRING DURING ICE-FREE PERIOD.
- INDICATES PERCENT OF TOTAL WIND MOVEMENT OCCURRING DURING COMBINED ICE AND ICE-FREE PERIODS.

FIGURES AT ENDS OF BARS INDICATE PERCENT OF TOTAL WIND DURATION FOR ICE-FREE PERIOD AND COMBINED ICE-FREE AND ICE PERIODS, RESPECTIVELY.

WIND DATA BASED ON RECORDS OF THE U.S. COAST GUARD AT LORAIN HARBOR, OHIO FOR PERIOD 1 JAN. 1938-31 DEC. 1971

FIGURE 2.6

revealed that the most frequently caught fish species in the Vermilion area include cat fish (Ictalurus ssp), white bass (Marone Chrysops), white crappie (Pomoxis annularis), yellow perch (Perca flavescens), and fresh water drum (Aplodinotus grunniens). Occasionally, salmonid species and walleye (Stizostedion vitreum) are caught. The beach area and associated substrate is not expected to provide a very productive fishery habitat.

Natural Environment

Climate

Vermilion's location on the Lake Erie Shore serves to influence several climatological features of the area, including the frequency and intensity of storms, lake winds, and ice conditions, as well as precipitation patterns. Its climate is marked by large annual and day-to-day changes in temperature ranging from 105° to -15° F during the period of record from 1936 to 1965. Temperatures are warm during the summer and cold with considerable cloudiness during the winter, but moderated by lake breezes. Subzero temperatures are experienced three winters out of five. As shown in Table 2.3, July is the warmest month, and January the coldest. Annual precipitation averages 34.15 inches, with more rain occurring during the summer. Winter snows average 29 inches per year. Historical records show that the Vermilion Harbor area is subject to freezing from approximately 15 December to 15 March, and at least some freezing of the harbor occurs during 90 percent of the time in winter. During the time of maximum ice cover in a normal winter (20 to 28 February), more than 95 percent of the lake may be frozen to depths ranging from 10 to 18 inches. During spring breakup, the area between the breakwater and the piers is sometimes unfrozen. In this case, ice flows coming down the harbor may jam against frozen lake ice and windrows at the east end of the breakwater (Plate 2.3). The Vermilion area is also subject to windrow ice which can accumulate to depths of 20 feet or more. The shoreline in the vicinity of Vermilion Harbor may stay frozen until 15 March. (Reference, Rondy, D. R., "Great Lakes Ice Atlas," National Oceanic and Atmospheric Administration, U.S. Department of Commerce, September 1971.) Ice breaking operations in the Vermilion Harbor are conducted by the U.S. Coast Guard in the approach and entrance channels; and by local commercial fishing interests, marina operators, and private Contractors in the river channel.

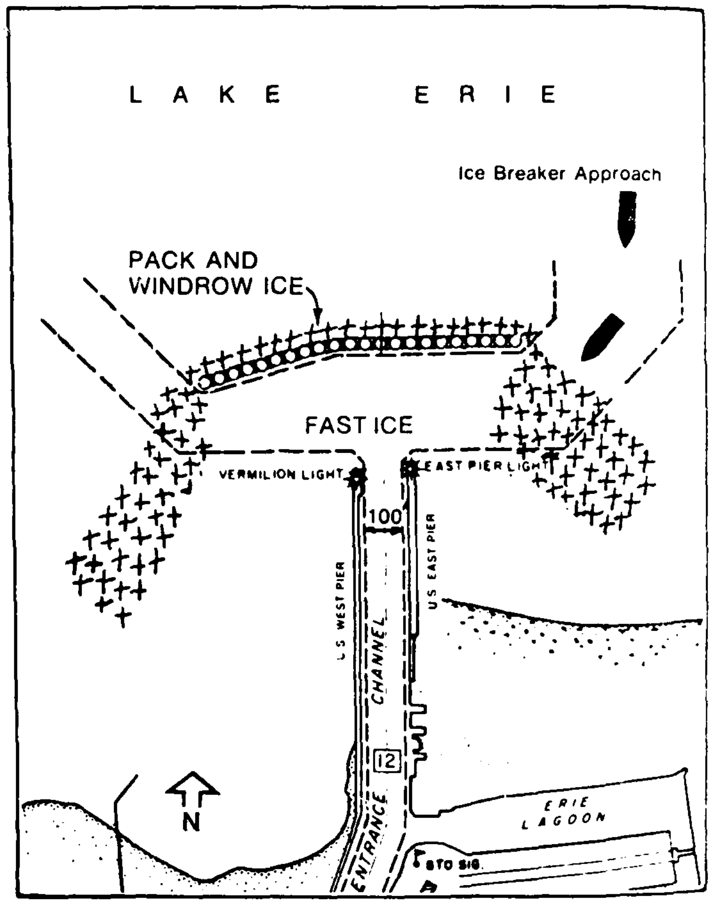
Soils & Geology

The importance of soils and geology to the project activities stems from factors such as erodibility and land use capability. The Vermilion region is characterized by relatively undisturbed, nearly horizontal sedimentary rocks ranging in age from the Cambrian to the Devonian period. The rocks are interbedded limestones, dolomites, sandstones, and shales. A generalized, geologic cross section of the Vermilion area is shown on Figure 2.7 (Reference, Herdendorf, C. E., Geology of the Vermilion West and Berlin Heights Quadrangles, Erie and Huron Counties, OH, Division of Geological Survey, Report No. 60, Columbus, OH, 1966.) The surfacial materials in the vicinity of the project areas are unconsolidated clay, sand and gravel deposits laid down either by the Wisconsin ice sheet or by glacial lakes preceding Lake Erie. Soils immediately to the east and west of the harbor entrance belong to Marsh and Beach Associations, consisting of layers of sand of various sizes and of fine gravel. These soils are used for recreational

Table 2.3 - Climatological Summary
Sandusky, OH, 1936-1965
(Means and Extremes)

Temperature (°F)															Precipitation Totals (Inches)															
Means				Extremes							Mean Number of Days Max.		Min.								Snow, Sleet						Mean Number of Days			
Month	Daily Minimum	Daily Minimum	Monthly	Record Highest	Year	Day	Record Lowest	Year	Day	Mean Degree Days**	90° and Below	32° and Below	32° and Below	0° and Below	Mean	Greatest Monthly	Year	Greatest Daily	Year	Day	Mean	Maximum Monthly	Year	Greatest Daily	Year	Day	.01 or More	.10 or More	.50 or More	1.00 or More
Jan	34.4	20.9	27.6	78	50	25	-15*	63	24	1153.	0	13	27	1	2.40	6.58	37	2.03	59	21	7.2	17.7	57	5.8	56	30	13	5	1.1	.3
Feb	36.2	22.1	29.1	72	44	26	- 7*	63	22	1010.	0	10	24	0	2.19	4.53	50	1.87	50	13	6.3	15.3	62	5.2	60	25	11	5	.8	.3
Mar	44.5	29.5	37.0	84	38	22	0	43	8	864.	0	4	20	0	2.88	5.23	64	2.01	48	21	5.8	12.6	60	7.9	60	3	13	7	1.6	.3
Apr	57.3	40.0	48.6	90	42	30	19	64	1	496.	0	0	4	0	2.23	7.19	61	1.77	59	28	1.1	12.0	57	4.5	57	8	13	7	2.0	.3
May	69.5	51.1	60.3	93*	62	20	34*	63	1	196.	0	0	0	0	3.41	9.04	43	3.83	38	19	.0						12	7	2.1	.5
Jun	79.4	61.0	70.2	101	52	26	42	47	4	29.	4	0	0	0	4.11	12.51	37	5.63	37	25	.0						11	7	2.6	1.0
Jul	83.4	65.4	74.4	105	36	14	51*	47	20	1.	6	0	0	0	3.62	9.71	43	2.92	61	19	.0						9	6	2.2	1.1
Aug	82.1	64.1	73.1	102	36	22	45	46	30	5.	4	0	0	0	3.23	6.96	56	2.72	54	14	.0						8	5	2.2	.8
Sep	75.4	56.7	66.0	90	53	1	34	56	21	79.	2	0	0	0	2.80	7.72	50	3.45	61	1	.0						8	5	1.7	.5
Oct	64.3	46.6	55.5	93	53	3	25*	66	31	311.	0	0	1	0	2.02	4.91	54	1.77	59	6	.0	.1	37+	.1*	39	28	8	4	1.1	.3
Nov	49.6	35.0	42.3	82	50	1	3	58	30	679.	0	1	11	0	2.22	4.89	50	1.49	62	10	2.5	19.8	50	12.3	50	25	11	5	1.2	.2
Dec	37.5	24.9	31.2	69	41	4	- 7	60	23	1043	0	9	23	0	2.04	5.74	51	1.68	40	29	6.1	20.2	51	7.0	62	7	11	5	.9	.2
Year	59.4	43.1	51.2	105	Jul 36	14	-15	Jan 63	23	5866.	16	37	110	1	34.15	12.51	Jun 37	5.63	Jun 37	25	29.0	20.2	Dec 51	12.3	Nov 50	25	128	68	20.	6

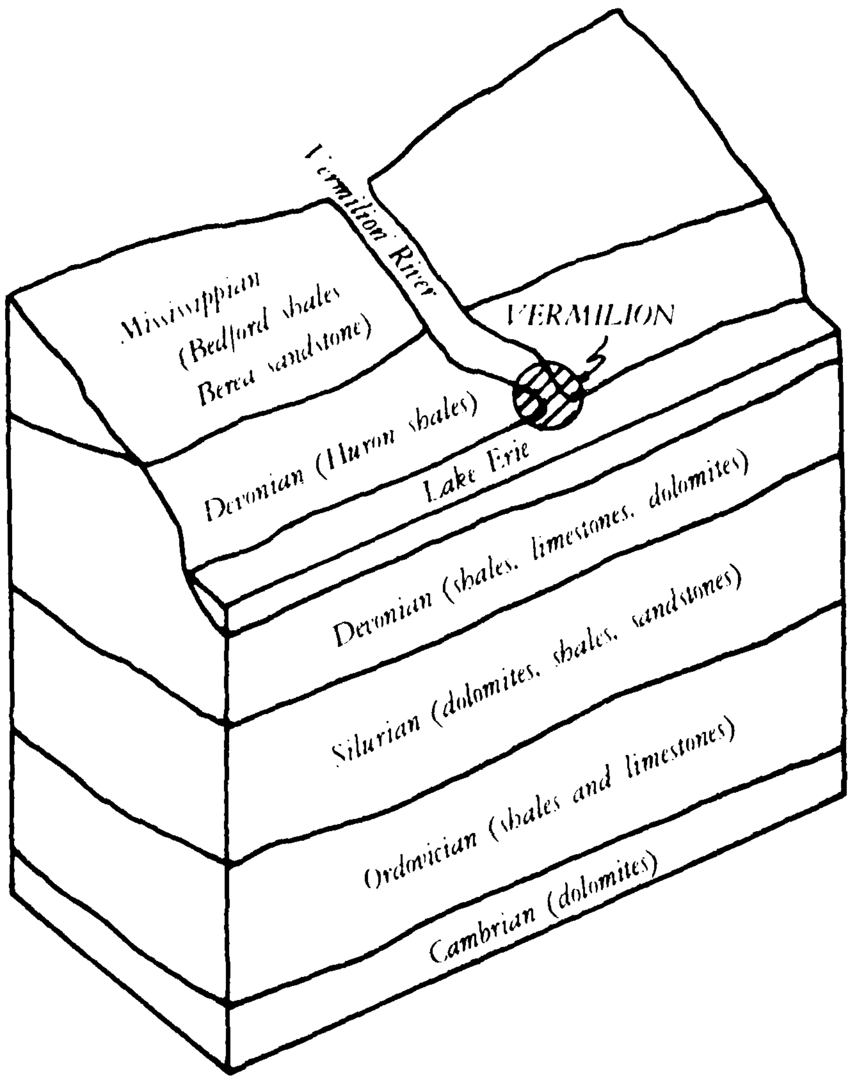
* Also on earlier dates, months, or years
** Base 65°F



NOTE:

ICE CONDITIONS AND ICE BREAKER APPROACH AFTER CONSTRUCTION OF THE OFFSHORE BREAKWATER AT VERMILION. WITH BREAKWATER, PACK ICE BLOWN BY THE WIND TENDS TO BUILD UP AT THE EAST AND WEST LAKE APPROACH CHANNELS.

ICE CONDITIONS



NOTE:
MAP NOT TO SCALE

GENERALIZED GEOLOGIC SECTION

FIGURE 2.7

purposes. Their granular nature causes them to be highly susceptible to erosion. The relative location of these soil associations are shown on Plate 2.4. The mineral resources located within the Vermilion River Watershed include sand and gravel deposits near Greenwich, located about 35 miles south of Vermilion Harbor in the southern portion of the basin. There are no known deposits of oil or gas in the watershed or near the lake disposal site.

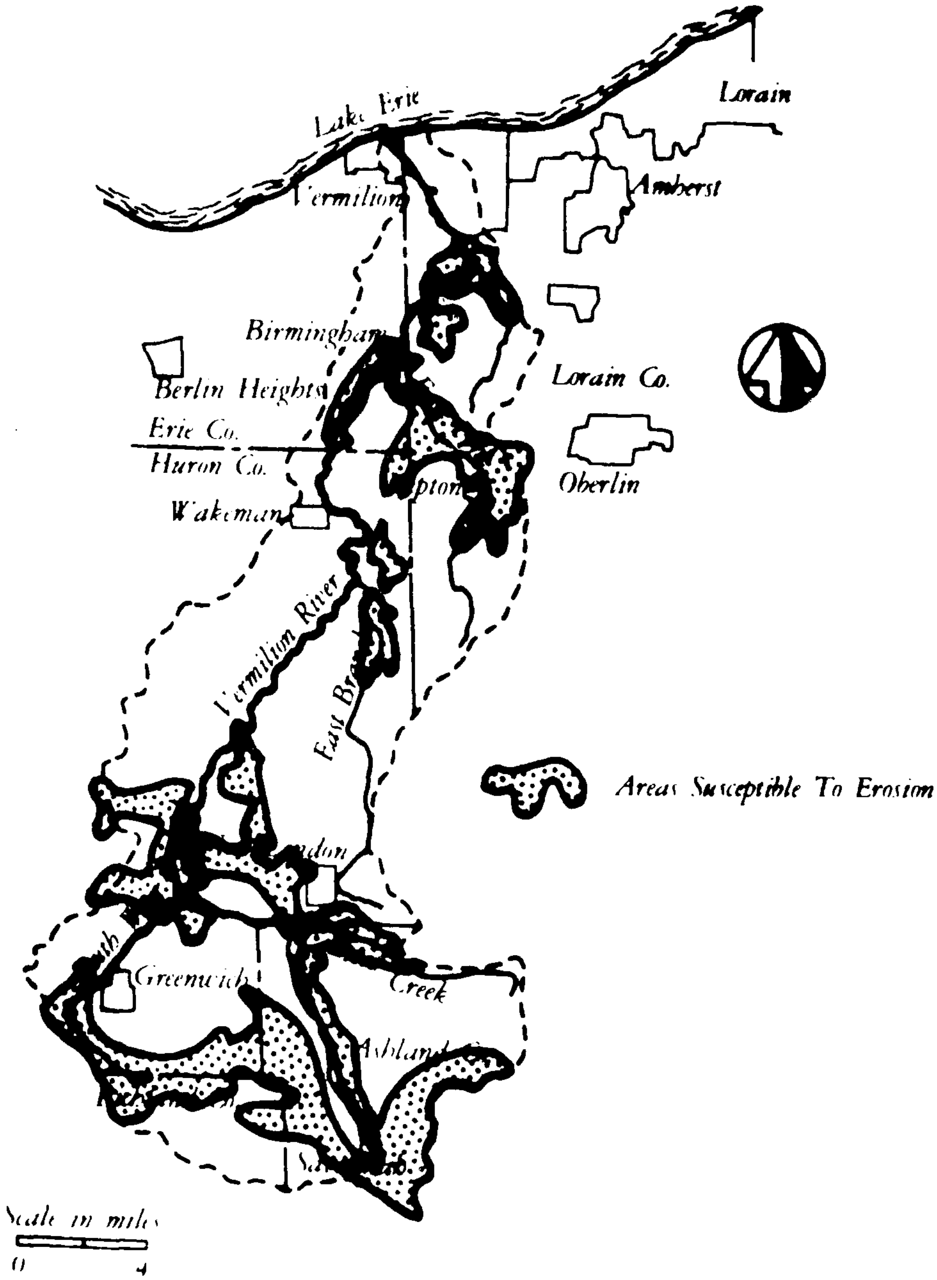
Sediment

The primary source of sediment in the harbor area is eroding soil from predominantly agricultural lands in the Vermilion River watershed. This soil is delivered to and transported by the Vermilion River to the harbor. Other sources are settleable solids discharged from the sewage treatment plant; bluff and shoreline erosion updrift of the harbor area; and material carried by littoral currents. In 1974, the Vermilion Wastewater Treatment Plant discharged an average of 17 mg/l of suspended solids at an average flow of .93 million gallons per day. The resulting load on the river was approximately 25 tons per year, which was very small in comparison with the 133,000 tons per year transported by the river to the project area. (Reference Gladdish, R., Vermilion Wastewater Treatment Plant Records, 1974, unpublished summary.) The general locations of soil throughout the Vermilion River Watershed which are susceptible to erosion are shown on Plate 2.4.

Little sediment material comes from bluff erosion or near shore lake bottom sources in the immediate harbor area. This is due to the shale bedrock composition of these potential sediment sources. As evidenced by the EPA analysis of sediments collected in the river channel near the end of the piers and in the lake approach areas, much of the sediment in this portion of the harbor is composed of sand and is suitable for restricted lake disposal (Plate 2.5). Materials carried in littoral drift (generally east to west in the Vermilion area) are the source of these sandy sediments which are generated from updrift areas in Lake Erie, located to the east of Vermilion. (Reference, U.S. Environmental Protection Agency, Region V, Great Lakes Surveillance Branch, "Vermilion, Ohio, Report on the Dredge of Pollution of Bottom Sediments," 9 April 1975.) However, successive sediment samplings have revealed that sediments at the Entrance Channel were silt, clay or sandy silt. For example: samples taken in 1978 (see page 27.1) revealed that most of the sediment was silt and clay.

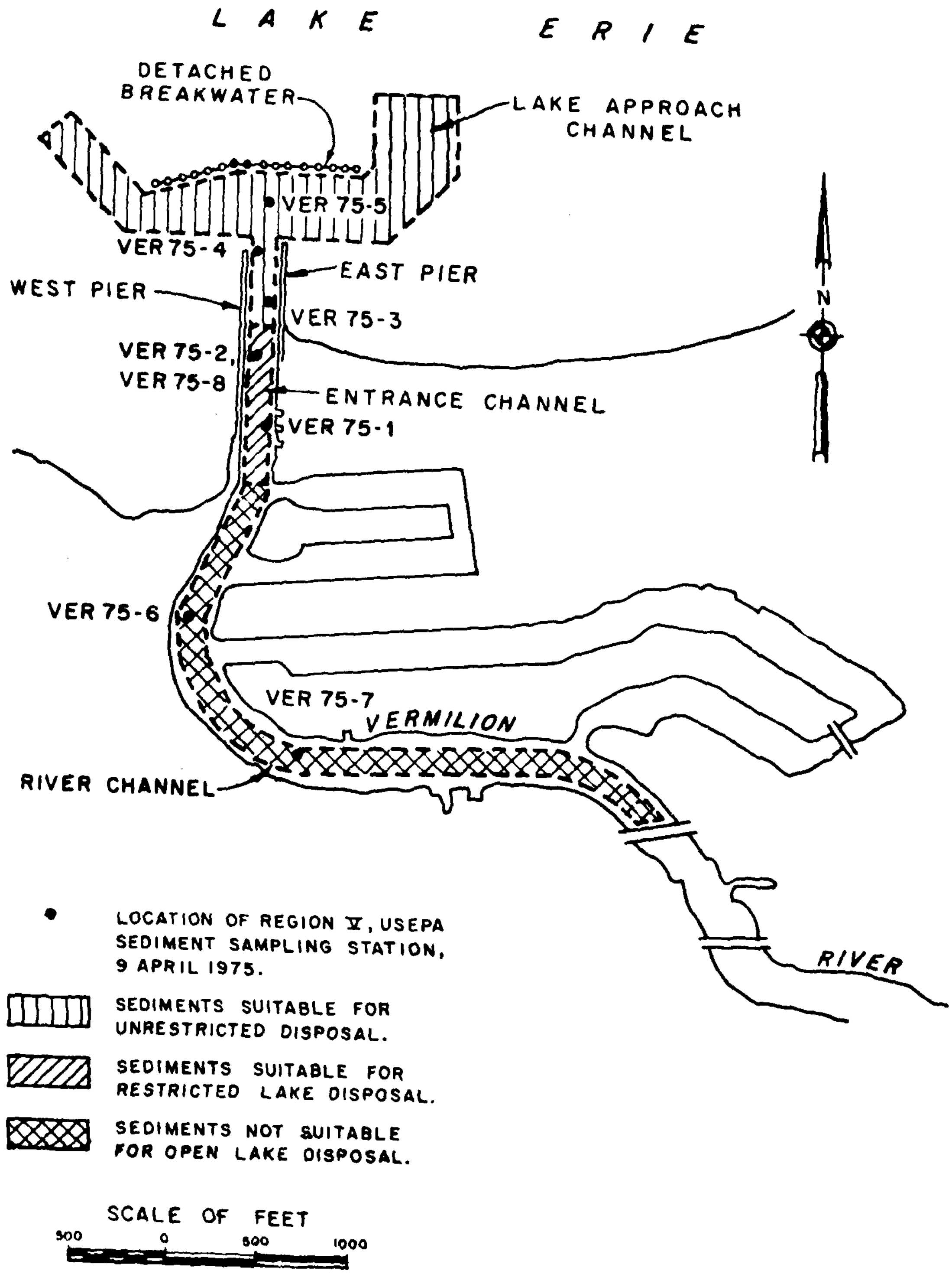
Fisheries

Lake Erie has provided a valuable commercial fishery during the last one-hundred years. The fisheries have changed considerably as a result of pollution, over fishing, and introduction of alien species. Commercial fishing, however, still plays a significant economic role in the Vermilion area. Over 8 million pounds of fish were taken by commercial methods in 1974 from the Ohio Waters of Lake Erie. Sport fishing in the Vermilion area may be characterized as seasonal, with the months of June through October, rated by local fishermen, as being the most productive. Those species frequently caught include catfish, white bass, yellow perch, and freshwater drum. Because of seasonal migrations from the open-lake area to shallow water spawning areas, various other fish species exist in the Vermilion River. The Ohio Department of Natural Resources (ODNR) and the U.S. Fish and Wildlife Service report species such as chinook salmon, coho salmon, and smallmouth



SOILS SUSCEPTIBLE TO EROSION

PLATE 2.4



HARBOR SEDIMENT QUALITY ZONES, 1975

PLATE 2.5

Table 2.3.1 - Vermilion Harbor Samples: 12 July 1978
Laboratory Results

Sample Number	Base Point	Ray	Offset	Water Depth	Description	Laboratory Description	Percent Organic Content	Percent Finer by Weight Than No. 202
River Mouth								
1	604	200	200	12.8	Silty clay, heavy organic	Test not run on sand	2.2	-
2		230	100	12.8	Silty clay, heavy organic	Clay with organic material	8.8	89.0
East Entrance Channel								
3		320	100	12.8	Silty clay, heavy organic	Sand silty clay, with organic material	10.0	83.7
4		340	200	11.0	Silty clay, organic	Gravelly clay with organic material	4.7	78.7
5		0	200	9.6	Clayey silt, trace of sand organic	Silt with organic material	6.8	96.4
6		0	100	9.2	Sandy silt, trace clay and organic	Sandy silt with organic material	9.6	81.4
7		10	150	9.1	Sandy clayey silt with organics	Silt with organic material	9.0	96.4
8		10	250	11.3	Silty clay with organics	Clay with organic material	5.2	95.2
9		20	200	8.7	Silty fine sand, clay, and organic	Clay with organic material	3.3	85.6
10		30	250	11.4	Sandy silt with clay and organic	Sandy silt material with organic material	3.0	54.8
11		30	150	7.9	Fine sand (80%) with silt and clay	Silty sand with shells	2.2	32.1
12		30	100	5.8	Fine sand, trace of silt	Silty sand with organic material	2.1	21.6
13		40	200	8.1	Sandy clayey silt, organics	Silty sand with organic material	8.0	46.3
14		50	300	10.9	Silty sand, trace of clay	Silty sand with organic material	2.1	24.3
15		60	200	7.0	Clayey silty sand	Silt with organic material	3.8	93.6
16		60	100	5.3	Silty clayey sand	Silty sand with organic clay	4.4	[illegible]
17		70	300	9.1	Silty sand, trace of clay	Silty sand with organic material	3.0	35.5
18		70	400	10.8	Sandy clayey silt	Sandy silt with organic clay	6.0	85.3
19	601	290	300	-	Not taken			
20		310	300	-	Not taken			
West Entrance Channel								
21		310	200	5.2	Sandy silt	Silty sand with organic material	2.8	45.9
22		330	200	5.2	Silty sand with clay and silt layers	Silty sand with organic clay	2.8	41.9
23		330	100	4.9	Fine sand with silt	Silty sand with organic material	19.0	24.1
24		350	250	6.5	Fine sand with trace organic and silt	Silty sand with organic material	2.1	21.1
25		350	150	5.9	Clayey silt, organics	Sandy silt with organic material	4.4	62.8

bass may be expected to migrate into the river during the spring, early summer, and fall and will spawn provided the water quality and substrate are suitable. (References, Ohio Department of Natural Resources, Ohio Commercial Fish Landings for Lake Erie, 1972, 1973, and 1974; Cleveland Environmental Research Group, (CERG), "Field Survey of Vermilion Harbor, 1975.") As mentioned earlier, no specific data are presently available on fisheries for the beach area concerned, but the species reported above are those frequently caught.

Those fish species collected or expected to occur in the Vermilion Harbor area are presented in Table 2.4.

Water Quality

The lack of sewer lines in southeast sections of Vermilion may have a detrimental effect on the area's groundwater quality. This is especially true of the area along the east bank of the Vermilion River where there is a high density population using septic tank disposal which has the potential for causing poor well water in the area. Improved municipal sewage treatment facilities and stricter enforcement of industrial wastewater effluent limitations in areas bordering Lake Erie have succeeded in improving water quality in the lake; and this trend is expected to continue. Improved water quality in the lake should allow for upgrading of the potential faunal community, both aquatic and terrestrial.

However, there have been several isolated periods in recent years during stormy weather conditions in early summer months when the Erie County Health Department has temporarily suspended swimming activities at the City Beach.

Human Environment

Land and Water Uses

Consideration of land and water use patterns is helpful in determining the type and magnitude of impacts resulting from the existing project. Plate 2.6 illustrates land use in the harbor area. Residential land use is found on both sides of the Vermilion River in the harbor vicinity. Residential properties occupy both the west and east banks of the river. The harbor is accessible from local streets in Vermilion. The Vermilion River north of the Liberty Avenue Bridge and the lake entrance channel serve as a waterborne route and recreation area for small boats in the harbor. Approximately one-half of the area near the Vermilion Harbor is devoted to marine-related commercial activities. The Vermilion Yacht Club is located on the east side of the Vermilion River, between the Erie and Ontario Lagoons immediately inside the harbor entrance. Upstream where the river bends to the east, the area bordered by Liberty Avenue, Main Street and South Street is occupied by a series of marine-related enterprises, such as Kishman Fish, the Vermilion Boat Club, Parson's Marine and Industrial Service, the Snell Fish Company, etc... . Most of the land in the city of Vermilion beyond the harbor area is agricultural or underdeveloped. Residential land, 4.7 percent of the city's area, is concentrated in the area immediately adjacent to the harbor (east, south and west of the harbor) and the area 2 miles east of the harbor, formerly known as Vermilion-on-the-Lake.

Table 2.4 - Fish Species Collected or Expected to Occur
Vermilion Harbor Area, June 1975

Common Name	Scientific Name	River/ Harbor	Lake	Comments
Spotted gar	Lepisoteus oculatus	X^2	X^3	Endangered - no recent collection data from area
Alewife	Alosa pseudoharengus	X^0	X^1	Common - lake - forage
Gizzard shad	Dorosoma cepedianum	X^0	X^1	Extremely abundant - ubiquitous - forage
Mooneye	Hiodon tergisus	X^2	X^3	Endangered - lake - no recent records for area
Coho salmon	Oncorhynchus kisutch	X^0	X^1	Seasonally common - lake - sport
Chinook salmon	Oncorhynchus tshawytscha	X^0	X^2	Seasonally common - lake - sport
Rainbow trout	Salmo gairdneri	X^0		Uncommon - stream - sport
Rainbow smelt	Osmerus mordax	X^3	X^1	Seasonally abundant - lake - commercial forage
Quillback carpsucker	Carpoides cyprinus cyprinus	X^0	X^1	Rare - lake - commercial
White sucker	Catostomus commersoni	X^0	X^1	Abundant - ubiquitous - commercial
Lake chubsucker	Erimyzon sucetta	X^2	X^3	Endangered - rare - lake
Spotted sucker	Minytrema melanops	X^0		Rare - stream
Golden redhorse	Moxostoma erythrurum	X^0	X^1	Common - ubiquitous - commercial
Goldfish	Carassius auratus	X^0	X^1	Abundant - lake - commercial

Table 2.4 - Fish Species Collected or Expected to Occur
Vermilion Harbor Area, June 1975 (Cont'd)

Common Name	Scientific Name	River/ Harbor	Lake	Comments
Carp	Cyprinus carpio	X^0	X^1	Abundant - ubiquitous - commercial
Silver chub	Hybopsis storeriana	X^2	X^3	Endangered - lake - forage
Emerald shiner	Notropis atherinoides	X^0		Abundant - ubiquitous - forage
Striped shiner	Notropis chrysocephalus	X^0		Abundant - stream - forage
Spottail shiner	Notropis hudsonius	X^0		Uncommon - lake - forage
Pugnose minnow	Notropis emiliae	X^2		Endangered - rare - stream
Yellow bullhead	Ictalurus natalis	X^0	X^2	Common - ubiquitous - sport
Brown bullhead	Ictalurus nebulosus	X^0	X^1	Common - ubiquitous - sport
Channel catfish	Ictalurus punctatus	X^0	X^1	Common - ubiquitous - commercial - sport
Stonecat	Noturus flavus	X3	X^1	Common - ubiquitous - forage
Flathead catfish	Pylodictis olivaris	X^2	X^3	Rare - lake
White bass	Morone chrysops	X^0	X^1	Abundant - ubiquitous - commercial
Rock bass	Ambloplites rupestris	X^0	X^1	Common - ubiquitous - sport
Smallmouth bass	Micropterus dolomieui	$X^{0,1}$	$X^{1,2}$	Uncommon - ubiquitous - sport
Largemouth bass	Micropterus salmoides	X^3		Common - ubiquitous - sport
Bluegill	Lepomis macrochirus	X^0		Common - stream - sport

Table 2.4 - Fish Species Collected or Expected to Occur
Vermilion Harbor Area, June 1975 (Cont'd)

Common Name	Scientific Name	River/ Harbor	Lake	Comments
Pumpkinseed sunfish	*Lepomis gibbosus*	X^0		Abundant - ubiquitous - sport
White crappie	*Pomoxis annularis*	X^0	X^1	Common - ubiquitous - sport
Yellow perch	*Perca flavescens*	X^0	X^1	Abundant - ubiquitous - sport - commercial
Walleye	*Stizostedion vitreum*	X^0	X^1	Rare - lake - sport - commercial
Freshwater drum	*Aplodinotus grunniens*	X^0	X^1	Abundant - lake - sport - commercial

LEGEND:

X^0 - Collected in harbor area July 1975.
X^1 - Collected by Ohio Department of Natural Resources 1970 and 1972.
X^2 - Reported to exist in area by Ohio Department of Natural Resources 1975.
X^3 - No collection data available but expected to occur in area due to wandering.

Extremely Abundant - Present in hugh concentrations; utilizing proper technique, they are normally extremely easy to collect and comprise a major percentage in most collections.

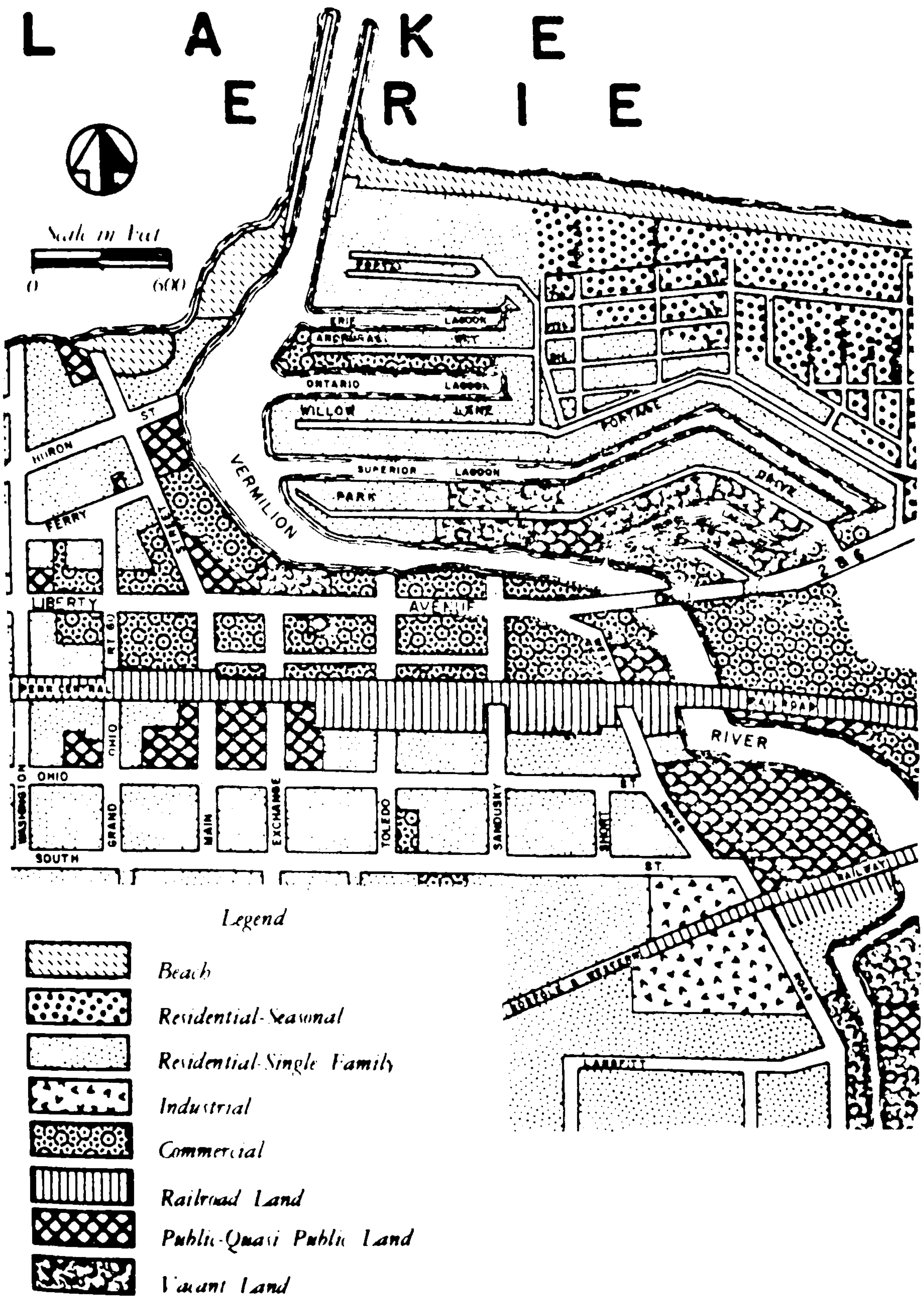
Abundant - Present in fairly large concentrations; occurring in most collections, sometimes in considerable numbers.

Common - Sufficiently numerous to be present, at least in some numbers, in almost every collection.

Uncommon - Usually present in small numbers, at least a few individuals in some collections.

Rare - Present in only a very few collections and then represented by only one or a few individuals.

SOURCE: Final Environmental Impact Statement, Operation and Maintenance, Vermilion Harbor, Erie County, OH - March 1976.



GENERALIZED LAND USE

PLATE 2.6

Water uses in the vicinity of the harbor include recreational boating, fishing, swimming, transportation, public drinking water, waste disposal, water skiing, scuba diving, canoeing, ice skating, ice hockey, snowmobiling, and sightseeing. Locations and times of occurrence of each water use activity are shown on Table 2.5. Vermilion's water is supplied through the City Water Department. Treatment is accomplished through application of fluoride, chlorine, alum, and lime. A modified activated sludge plant, built in 1968, is used for sewage treatment. Approximately 30 trailer parks, motels, and small businesses operate septic tanks which discharge or leach into Lake Erie along the shore, west of Vermilion.

Recreation

Recreational opportunities in a city represent a basic resource which may stimulate future growth and development. In the Vermilion Harbor area, recreational patterns are prime indicators of the harbor's importance to the community. The number of boaters, fishermen, and other recreational users of the harbor helps gage the importance of recreational trade in the overall commerce and business present in the city, and the potential impacts of water-related activities.

Recreational activities in Vermilion and its vicinity are highly seasonal and quite diversified. Boating is a prime activity within the project area. The majority of boaters using Vermilion Harbor are not from Vermilion but rather from areas where docking facilities are insufficient or nonexistent. An estimate of total annual harbor usage by recreational boaters is given in Table 2.6.

Other prime recreational activities in and near the project area are fishing and swimming. Fishing is practiced in conjunction with boating. There is little fishing off the piers and the breakwater because of limited access to the East and West Piers due to private property and restricted access to boats near the breakwater. Swimming is prevalent off the marina docks in the river and lagoons, in Lake Erie at the foot of Main Street, and at private beaches. A description of bathing beaches is given in Table 2.7. Additional water-related summer activities include water skiing outside the breakwater area, scuba diving from boats or off shore, canoeing (especially in the river and lagoons) and camping upstream along the banks of the Vermilion River. Local residents enjoy a variety of winter recreational activities on or near the harbor and river, including ice skating and hockey, snowmobiling and sledding. There are five parks in the city of Vermilion, as shown on Plate 2.7. Sherod Park and Showse Park are the largest. Their facilities include baseball diamonds, picnic tables, grills, playgrounds, nature trails, and unmanaged beaches. Exchange Park, at the corner of Liberty Avenue and Main Street has park benches and a memorial to soldiers from Vermilion who died in past wars. In addition, the Lorain County Metropolitan Park District maintains the Vermilion River Reservation along the river, south of the city which consists of 217 acres, and includes hiking, picnicking and camping facilities. Two public golf courses are located within the Vermilion vicinity. Additional recreational facilities within Vermilion include a bowling alley and a miniature golf course on West Liberty Avenue, and enclosed pools at the YMCA and Valley View Pool.

Table 2.5 - Water Use, Vermilion Harbor

Activity	Breakwater	Piers	Lagoons	River Channel	Lake Approach Channel	Open Lake	Beaches	Months During Which Prime Use Occurs
Sailing			•	•	•	•		June-September
Recreational Boating			•	•	•	•		June-September
Recreational Fishing	•*	•*	•	•	•	•	•	June-October
Commercial Fishing Operations				•	•	•		March-December
Swimming, Sunbathing	•*	•*	•	•			•	June-September
Scuba Diving	•*	•*	•	•		•	•	June-September
Ice Skating, Hockey			•					December-March
Snowmobiling				•				December-March
Walking		•*					•	All Year
Boat Dockage and Launch			•	•				April-November
Water Skiing						•		June-September
Water Intake						•		All Year
Army Corps Maintenance of Harbor Facilities	•	•		•	•	•		June-September
Wastewater Disposal				•				All Year
Sightseeing, Photography		•*	•	•	•	•	•	All Year
Canoeing			•	•				June-September

* Activity only occasional due to limited access

SOURCE: Final Environmental Impact Statement, Operation and Maintenance, Vermilion Harbor, Erie County, OH, March 1976.

Table 2.6 - Harbor Usage by Recreational Boaters (Estimated)
Vermilion, 1975

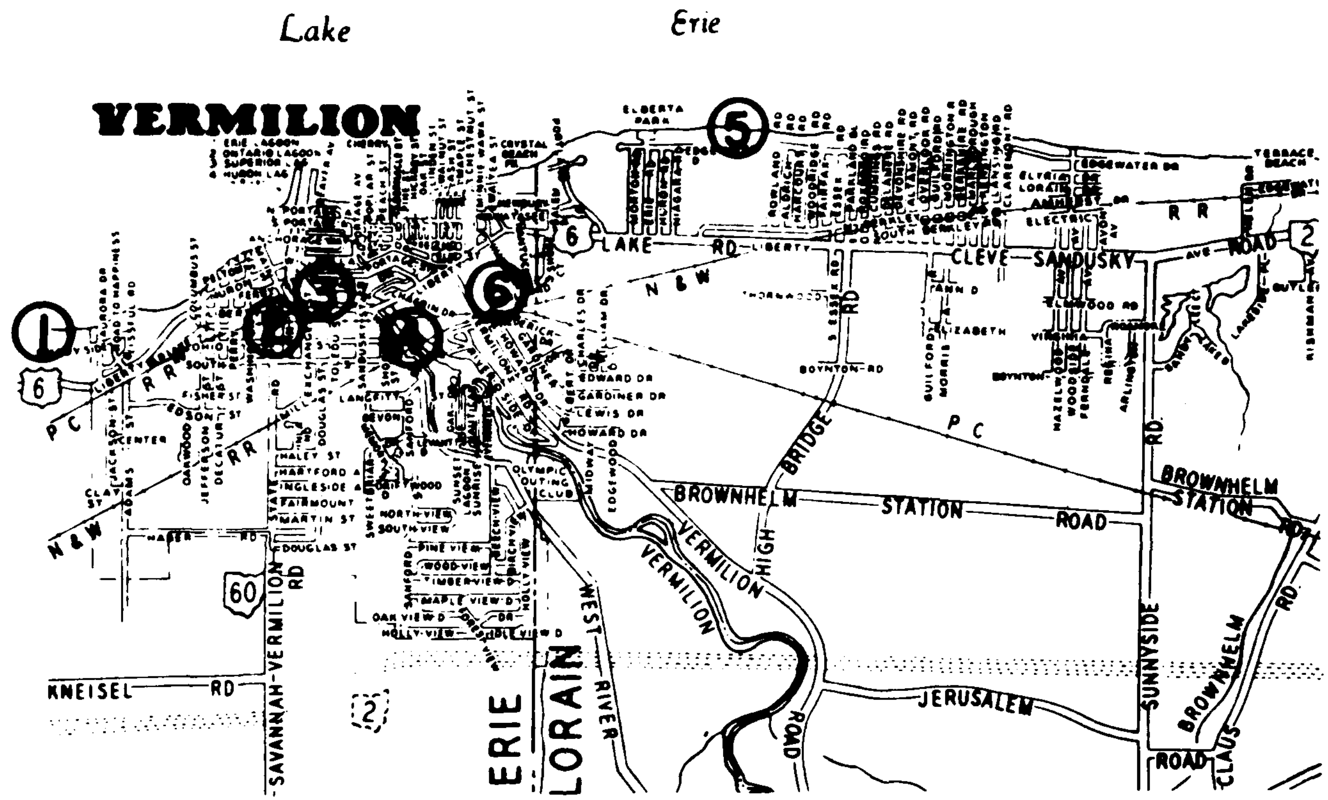
Power Boats Permanently Docked at Marinas and Boat Clubs	857
Sail Boats Permanently Docked at Marinas and Boat Clubs	60
Boats Permanently Docked at Lagoons (Estimate)	100
Boats in Dry Storage in Vermilion, Used at Least Once Per Year	1,017
Boats Owned by Nonresidents of Vermilion, Launched in Vermilion at Least Once Per Year	2,000
Annual Visitors Whose Trips Originate in Other Ports	2,000
Total, Annual Number of Boats Which Use Vermilion Harbor at Least Once Per Year	6,034

SOURCE: RETA Field Survey, 17-20 June 1975

Table 2.7 - Bathing Beaches, Vermilion Harbor

Beach	Location	Size		Access	Responsible for Maintenance	Season
		Width (feet)	Length (feet)			
City Beach	Foot of Main Street	100	200	Public	City of Vermilion	June-October
Lagoons Beach	East of East Pier	100	800	Residents of Lagoons Vicinity	Vermilion Lagoons Association	June-October
Linwood Park Beach	Linwood Park Lakeshore	100	1,000	Residents of Linwood Park and Public (Fee Charged)	Linwood Park Company	June-September

SOURCE: Ryckman/Edgerley/Tomlinson and Associates, 1975.



1. SHEROD PARK
2. VICTORY PARK
3. EXCHANGE PARK
4. PUBLIC BOAT LAUNCH AND PARK
5. SHOWSE PARK
6. Y.M.C.A.

SOURCE: RYCKMAN/EDGERLY/TOMLINSON AND ASSOCIATES, 1975

PARKS AND RECREATION

Demography

Population trends and general growth of the city may be related to expansion and maintenance of harbor activities. The 1980 population of the city of Vermilion (11,012) represents an 11.5 percent increase in population since 1970 (9,870), and an 81.7 percent increase since 1960 (6,060). In 1970, 40.2 percent of the population was under 18 years of age and 94.4 percent under 65 years of age. There were 2,804 households in Vermilion in 1970, with an average family size of 3.5 people per household. Approximately 64.6 percent of the community's houses were owner-occupied. Approximately one-half of Linwood Park's permanent occupants are retired. While the residential areas adjacent to the lagoons are permanent residences, many of their inhabitants would spend part or all winter time in a warmer climate. Many of the cottage residences are now occupied on a year-round basis, and the influx of a temporary summer population is limited by the availability of seasonal housing. Many people reside in their boats which are moored in marina slips during the boating season. (Reference, Lorain County Regional Planning Commission, "Regional Housing Study," Report No. 19, Elyria, OH, 31 January 1974.)

Employment, Income, Industries

Vermilion's labor force of 3,545 persons included 2,583 men and 962 women (1970 census). The largest single employer of Vermilion residents was the Ford Truck Plant (approximately 5 miles east of the city), employing between 500 and 1,000 residents. The largest employer within the city of Vermilion was the ITT Wakefield plant which employed 250 persons. A summary of major industries in Vermilion is given in Table 2.8. Males were employed primarily as craftsmen; females in the work force were primarily employed as clerical workers, service workers and teachers. Very few Vermilion residents were employed in the farm industry. A breakdown of occupational types among residents of Vermilion is given in Table 2.9. In 1970, the median family income was $11,444 and the per capita income was $3,355. Self-employed persons earned substantially less than persons salaried by private companies. More information on family income is presented in Table 2.10.

Cultural Opportunities

Knowledge of existing cultural resources indicates the importance of the harbor to overall community prosperity and its influence on cultural activities in the Vermilion area. Cultural activities are closely related to its standing position as the largest small-boat harbor on Lake Erie. Every third weekend of June, the Chamber of Commerce sponsored an annual Festival of Fish; activities include model boat shows, boat rides, sail races, fish fries, a review of fleet and an annual antique boat parade; the South Shore Regatta is highlighted in August by the annual Inter-Lake Regatta Race from Put-in-Bay to Vermilion. Other festivals held in nearby cities and towns and attended by many Vermilion residents include the International Festival in Lorain, and a Water Festival in Huron. Vermilion's historical heritage is also closely tied to its harbor activity. The Great Lakes Historical Society Museum on Main Street contains a large collection of ship models, marine relics, and paintings.

Table 2.8 - Summary of Industry
Vermilion, 1975

Industry	Address	Number of Employees	Products
Bettcher Industries	Route 60 at the turnpike	70	Meat processing equipment
Crow Lumber Co.	666 West River Road	15	ARCRO Homes, MINI Barns
Firelands Originals	1091 Sunnyside Road	5-10	Hand-made furniture
Gentry, International	993 State St.	18	Seasonings, spices, food, beverage mixes
ITT Wakefield-Lighting Fixture Div. Art Metal Div.	850 W. River Road	250	Industrial lighting fixtures
Kishman Fish Co.	573 River Road	27-50	Retail and wholesale fresh and frozen seafood
Klingshirm Builders	4550 Liberty	N/A	N/A
Masonry Seal Corp.	5499 Liberty	N/A	Concrete masonry sealer
SAMCO	5520 Mill St.	N/A	Truck bodies
South Shore Packing Co.	5117 South St.	50	Imported olives
Wonder Color Co.	1030 Douglas St.	12	Color pigments
Vermilion Engineering Co.	4165 Liberty	N/A	Welding and prefabricating

N/A = Not available

SOURCE: Final Environmental Impact Statement, Operation and Maintenance, Vermilion Harbor, Erie County, OH - March 1976.

Table 2.9 - Occupation of Employed Residents*
Vermilion, 1970

Category	Subcategory	Number	Percentage
Total employed		3,545	100.0
Professional, technical and kindred		523	14.8
	Health workers	70	2.0
	Teachers	180	5.1
Managers and administrators		326	9.2
	Salaried	278	7.8
	Self-employed in retail trade	29	0.8
Sales workers		213	6.0
	Retail trade	99	2.8
Clerical and kindred		438	12.3
Craftsmen, foremen and kindred		662	18.7
	Mechanics and repairmen	149	4.2
	Construction craftsmen	154	4.3
Operatives (except transport)		715	20.2
	Manufacturing	611	17.2
	Nonmanufacturing	104	3.0
Transport equipment operators		216	6.1
Laborers (except farm)		122	3.4
Farmers and farm managers		10	0.3
Farm laborers and foremen		7	0.2
Service workers		305	8.6
	Cleaning and food service	193	5.4
	Protective	21	0.6
	Personal and health service	78	2.2
Private household workers		8	0.2

* 16 years of age or older.

SOURCE: Final Environmental Impact Statement, Operation and Maintenance, Vermilion Harbor, Erie County, OH, March 1976.

Table 2.10 - Family Incomes
Vermilion, 1970

Category	Number	Percent
Total	2,479	100.0
Less than $1,000	32	1.3
$1,000 to 1,999	24	1.0
$2,000 to 2,999	81	3.3
$3,000 to 3,999	56	2.2
$4,000 to 4,999	58	2.3
$5,000 to 5,999	52	2.1
$6,000 to 6,999	75	3.0
$7,000 to 7,999	108	4.3
$8,000 to 8,999	219	8.9
$9,000 to 9,999	198	8.0
$10,000 to 11,999	466	18.8
$12,000 to 14,999	473	19.1
$15,000 to 24,999	529	21.3
$25,000 to 49,999	84	3.4
$50,000 or more	24	1.0

SOURCE: Final Environmental Impact Statement, Operation and Maintenance, Vermilion Harbor, Erie County, OH, March 1976.

Activities and facilities in the immediate project area center around water-related recreation and commerce. There are, as mentioned earlier, several public beaches, parks, and municipal docks as well as a number of marinas and boat clubs.

The annual Festival of the Fish in June, the South Shore Regatta in August, and the Grand Opera performances by the Visiting Bowling Green University Music Department each February are events which highlight the social and cultural activities of the area. As mentioned above, there is an estimated seasonal population increase in Vermilion of approximately 5,000 persons who mostly rent summer homes in the Linwood Park area. This increase has been steady through the 1960's and projections indicate that this trend will continue for several years in the immediate future.

SECTION III

PROBLEM IDENTIFICATION

Problems, Needs, Concerns

The water resource problem fundamental to this investigation is that the existing Federally constructed breakwater at Vermilion Harbor has allegedly caused adverse impacts to the adjacent shoreline and the community as a whole, and polluted swimming areas by diverting the river water across the beaches. The breakwater was also alleged to be a physical and psychological obstacle to the development of recreational boating, fishing and swimming; and a hazard to navigation.

One of the local interest's primary concerns is the potential relationship of the breakwater to the shoreline, or beach erosion, east of the harbor. On 6 October 1975, the District Engineer met with Mr. George W. Grossman, a resident of the Linwood Park Community. At that meeting, the District Engineer explained the Corps procedures for resolving the local residents' concerns and complaints, and stated that the study of the shoreline changes that have been attributed to the Federal navigation project could be performed under Section 111 authority.

The Linwood Park residents' complaints include the adverse effects of the detached breakwater on public water supply, increased beach-water pollution, ice formation in the harbor, increased ice-jam flooding potential, increased free-flow flood potential, increased shoaling in the Federal and private lagoon navigation channels, land use changes and resultant changes in occupancy and property values, and increased navigation hazards. The Buffalo District has conducted an in-depth investigation of these alleged adverse effects that local interests have attributed to the presence of the detached breakwater. As noted previously, the results of these studies are presented in the companion Breakwater Impact Study Report. Based on these studies, it has been concluded that some changes have indeed occurred since breakwater construction. Prior to construction of the piers in the 1830's, the amount of littoral drift, pre-dominantly westward, was relatively small in the immediate vicinity of the Vermilion Harbor. A study of shoreline changes made in 1854 indicated temporary reversals in the direction of the littoral drift causing accretion and erosion adjacent to both the East and West Piers, with greater accumulations west of the West Pier.

In recent years, however, the accretion has been greater east of the East Pier. (Photo 3.1). Prior to construction of the breakwater in 1973, the Lagoons Beach immediately to the east of the East Pier was about 200 feet wide. Since construction of the breakwater, this beach has accreted an additional 300 feet, apparently due to the shadowing effect of the breakwater.

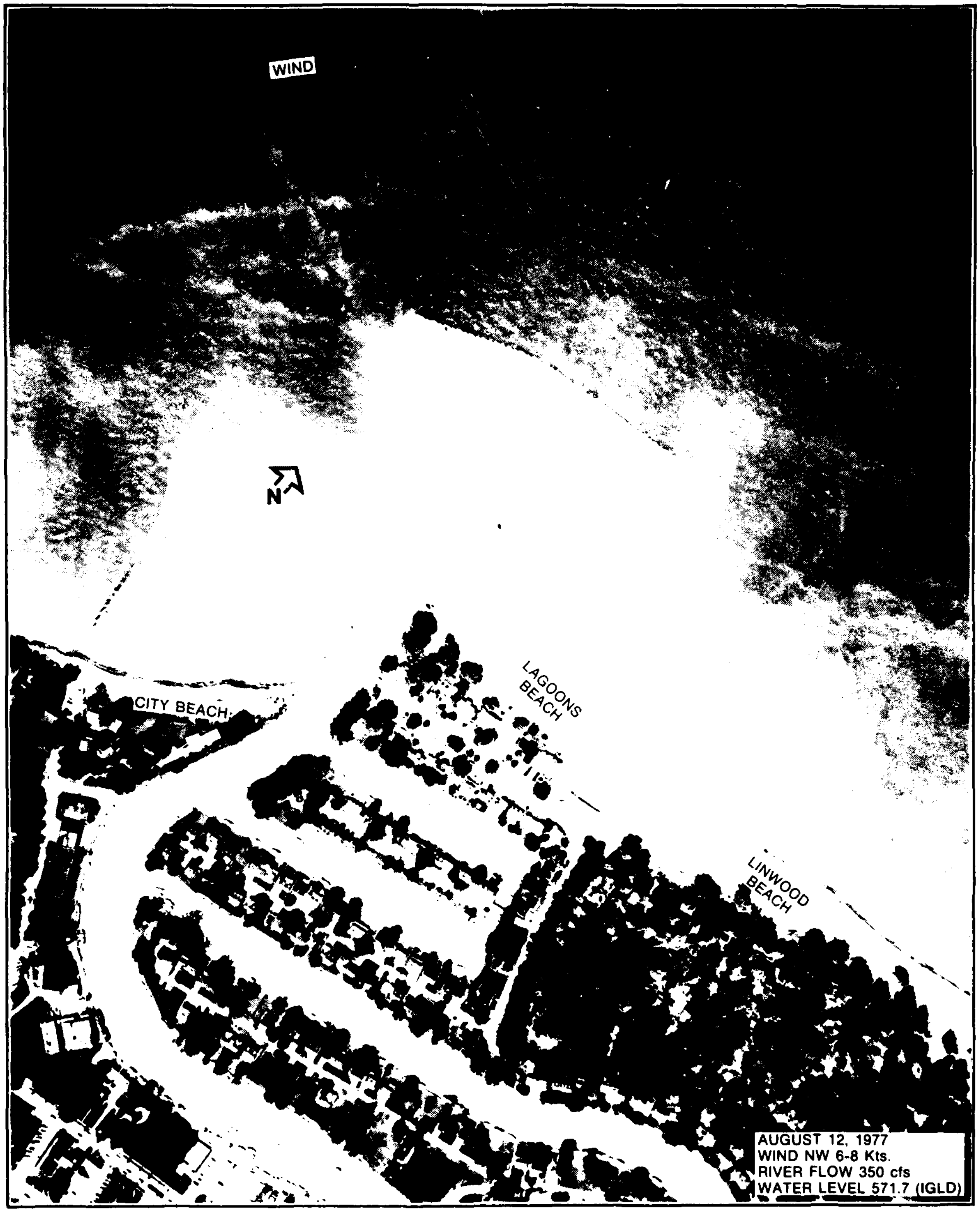

WIND
N
CITY BEACH
LAGOONS BEACH
LINWOOD BEACH
AUGUST 12, 1977
WIND NW 6-8 Kts.
RIVER FLOW 350 cfs
WATER LEVEL 571.7 (IGLD)

PHOTO 3.1

In the 1960's, Linwood Beach underwent a dramatic increase in usable beach area. However, there was a decline in beach area in the decade of the 1970's. Nakomis Beach underwent major reorientation during the 1958-1979 period. About 600 feet of beach at the eastern extremity of Nakomis Beach disappeared in the 1970's. (Photos 3.2 and 3.3). That beach has also experienced minimum surface area during periods when Lagoons Beach has seen its largest area. Some concerned local citizens associated the loss of beach area at Linwood and Nakomis with construction of the breakwater in 1973. Following are highlights of the views expressed by residents in written correspondence and at the public meeting held on 31 August 1978 at Vermilion, subsequent to completion of the Stage 2 investigation:

Rutledge Equipment Company wrote:

> " . . . Only the complete removal of the 'monstrosity' will be completely effective in returning the shoreline to the pre-1972 long-term equilibrium state. This action would be desirable to establish the long-term equilibrium at the right point." (Refer to Appendix D).

In a written statement to Buffalo District, dated 31 August 1978, and read at the public meeting, Mr. George W. Grossman concluded:

> "The breakwater was a very poor investment of public funds. Alternative No. 1, Removal of the Breakwater, is the best possible, most beneficial, and least expensive solution for Vermilion Harbor."

Mrs. Ann Peters, a Linwood Park property owner, stated during the meeting:

> "As far as we are concerned, there is only one way to eliminate what we may suffer for the rest of our lives, and that is the complete elimination of the wall."

The Linwood Park Cottage Owners Association, Inc., in a written statement dated 31 August 1978, to then Colonel D. Ludwig on Vermilion Harbor, commented:

> "We note and endorse Stanley Consultants conclusion that "only removal of the breakwater will be completely effective in returning the shoreline to the pre-1972 long-term equilibrium state." However, we disagree with their subsequent statements that removal as a solution would not retain protection for navigation. Those of our members who have operated small craft in and out of Vermilion Harbor believe that the project purposes of aiding commercial fishing and recreational boating, and providing a harbor-of-refuge were met by Vermilion Harbor in its 1876-1972 status, with parallel piers only. We do not feel that the detached breakwater is essential to the project, and there is a question whether the project's

Photo 3.2

About 600 feet of beach at the eastern end of Nakomis Beach disappeared. East end of Linwood Beach underwent some erosion reaching the bluff which protects the sewer outfall. Photo taken September 1977.

Photo 3.3

Part of Linwood Beach to the west of the outfall shown in photo 3.2 above eroded away in 1978 (Photo 3.3). Bluff protecting sewer outfall was totally exposed to wave attack. Nakomis Beach was non-existent. Photo taken May 1978.

> benefits from the breakwater have been attained. Therefore, we continue to maintain that removal of the breakwater would be the best alternative for eliminating the erosion, pollution, and flood hazard problems..."

The demand for structural modification or removal of the breakwater remains strong. Some local interest groups have suggested removal of the breakwater as a means of reducing outer harbor shoaling caused by the breakwater. The Vermilion Port Authority has suggested removing a submerged section of the breakwater to allow a more direct flow of river discharge into the lake. However, modification or removal of the structure would diminish or eliminate the ability of the total project to achieve its objectives of enhancing commercial fishing, recreational navigation, and providing a harbor-of-refuge for small crafts. Removal or modification would also reduce or negatively impact the benefits that the Vermilion Port Authority attributed to the presence of the structure.

Disposal of Vermilion Harbor Dredgings - Dredged material from the lake portion of Vermilion Harbor is presently disposed of at a designated and approved open-lake site approximately 2 miles north of the harbor. Material, both fines and sand, disposed of at this site is lost to the littoral zone. At a 14 August 1979 Section 404 public hearing on open-lake disposal of dredged material from Vermilion Harbor, a number of local residents requested that the disposal site be moved eastward and shoreward so that the beach-building material (sand), portion of the harbor dredgings can be returned to the littoral regime primarily to nourish Nakomis and Linwood Beaches. The District Engineer agreed that consideration should be given to relocating the disposal site, and has initiated coordination with the USEPA and USF&WS to determine the environmental viability of relocating the site nearer to shore.

In a letter to the District Engineer dated September 1980 (Appendix E), the U.S. Fish and Wildlife Service wrote:

> "General information available on the western Lake Erie fish and wildlife resources in the proposed disposal area leads us to believe that major detrimental impacts could occur if dredged material was deposited in the proposed disposal areas."

They also pointed out that for any anticipation of further study of this proposed relocation, specific data must be obtained in order to accurately predict the impacts on the fisheries of relocating the Vermilion disposal area. As part of the process for evaluating suitability of dredge material from the Harbor for beach nourishment with a view to relocating the disposal site, The Corps made new sampling efforts in 1981. The latest chemical and sieve analyses, done by Wadsworth Testing and Laboratory of Canton, Ohio, revealed that the material is polluted. Silt and clay have dominated the sediments which had high concentrations of arsenic, iron, ammonia, and oil and grease. Based on these results, nearshore disposal of dredged material to nourish bathing beaches at the Vermilion Harbor was not viable and therefore, was given no further consideration.

National Objectives

Federal Policy, as developed by the Water Resources Council, requires that the alternative water and related land resource plans be formulated in accordance with the national objectives of National Economic Development (NED) and Environmental Quality (EQ). Therefore, in accordance with the guidance established in Engineering Regulations 1105-2-200, "Multi-Objective Planning Framework," dated 13 July 1978, this study is consistent with the planning requirements of the Water Resources Council Principles and Standards (P&S), the National Environmental Policy Act of 1969 (NEPA), and related policies. In accomplishing the study, equal consideration was given to the P&S objectives of NED and EQ described below:

- National Economic Development (NED) - National Economic Development is achieved by increasing the value of the nation's output of goods and services and improving economic efficiency.

- Environmental Quality (EQ) - Environmental quality is achieved by the management, conservation, preservation, creation, restoration or improvement of the quality of certain natural and cultural resources and ecological systems.

Planning Objectives

The rationale used to develop alternative plans for mitigation of adverse impacts of the Vermilion Harbor Federal navigation structures on shore erosion and related potential impacts was that each plan should serve the planning objectives and must respond to needs and opportunities at the Vermilion Harbor and contribute to national economic development and environmental quality objectives. Two general planning objectives pursued during these studies were to respond to Section 111 of the River and Harbor Act of 1968, and address the national water and related land management objectives prescribed by the U. S. Water Resources Council. Each of these two general planning objectives is defined in terms of the following specific planning objectives which serve to guide the plan formulation process:

- If appropriate, mitigate shore erosion damages along Lake Erie shores adjacent to the Vermilion Harbor to overcome adverse impacts of the Federal navigation structures on the community as a whole during the period 1982-2032.

- Maintain the ecological value of the Vermilion Harbor in terms of diversity, wildlife, erosion control, and aesthetics during the period 1982-2032.

- Mitigate navigation hazards due to traffic congestion at the Vermilion Harbor along adjacent Lake Erie shores during the period 1982-2032, as appropriate.

- Lessen unacceptable pollution of swimming area and beaches, and ice jam and free-flow flooding at the Vermilion Harbor along adjacent Lake Erie shores to prevent adverse health effects on local residents during the period 1982-2032, if required.

- As appropriate, eliminate periodic contamination of municipal water supply in the Vermilion area to alleviate public health concerns during the period 1982-2032.

Studies related to most of the above specific planning objectives such as periodic contamination of municipal water supply, pollution of recreational swimming area, ice jam and free-flow flooding, and navigation hazards are not addressed under Section 111 authority. The result of the investigation of these problems is presented in a separate companion report to this document titled Vermilion Harbor, OH, Condition Survey Report.

SECTION IV

PERTINENT STUDIES MADE AND RELATED ACTIVITIES

In response to concerns expressed by some residents of Vermilion and at the request of the Ohio Department of Natural Resources, a number of studies have been conducted by the Buffalo District to determine the need to mitigate shoreline damages caused by the Vermilion Harbor navigation structures. The results of these studies, beginning with a preliminary study in 1975 and continuing to the present are discussed below.

Initial Section 111 Study

Several individual Section 111 studies have been performed for Vermilion Harbor, beginning with the District's initial study published on 21 January 1976 as a Preliminary Report on Section 111 Study of Vermilion Harbor, OH. This preliminary study was performed by the Buffalo District in 1975. Its purpose was to determine whether the Federal navigation improvements have caused or increased the erosion of the shore in the vicinity, and if so, to determine what measures are justified to mitigate the damages. This report recommended that no action be taken under Section 111, and that a 5-year monitoring program be initiated and followed by a supplemental Section 111 study based on the results of the monitoring program.

Section 111 Stage 2 Study (East of Harbor)

Stanley Consultants of Cleveland, OH, performed the investigation of the shoreline erosion problem; and the Buffalo District published in May 1978, a report titled Vermilion Harbor, Ohio, Section 111 Study - Impact of the Federal Navigation Structures on Shoreline Processes. The purpose of that study was to quantify the shoreline damages to the east of the harbor due to the offshore breakwater, and to develop alternative plans for mitigating the damages if mitigation is warranted. (Exhibit C.1 of Appencix C provides pertinent information.) The study involved the following basic work items:

(1) An investigation of erosion rates and shoreline redistribution through the use of aerial photographs and survey information.

(2) A detailed presentation and evaluation of the littoral processes governing the shoreline characteristics.

(3) A determination of the influence of the Federally constructed offshore breakwater on shoreline erosion, particularly to the east of the harbor.

(4) A sediment budget analysis.

(5) A quantitative evaluation of the shoreline realignment and beach distribution changes as related to the offshore breakwater.

(6) A recommendation as to whether mitigation measures are to be further considered.

Results of Stanley Consultants Investigation

The major areas of interest included the Vermilion City Beach, extending 500 to 600 feet west of the west pier, and Lagoons, Linwood and Nakomis Beaches extending approximately 4,000 feet to the east of the harbor channel.

The analysis of historical information established that a significant shift in beach material from east to west occurred from 1971 to 1976 on Linwood and Lagoons Beaches. A slight reversal occurred in late 1976 and 1977, as indicated by the beach profile and aerial photograph analysis in the Stanley's May 1978 report.

Also, accretion at the east pier and erosion at eastern Linwood Park began before the breakwater construction. The first shift in beach alignment began as a response to high lake levels and a slight predominance of northeasterly winds, and was accentuated by the trapping effect of the breakwater. This trapping of beach material by the breakwater occurs when sand is driven west to the piers by northeast storms and is then protected from subsequent exposure to northwest storms by the position of the breakwater. Under pre-breakwater conditions, the sand would be returned to the east by the northwest storms. On this basis, Stanley Consultants concluded that the breakwater has had an effect on beach orientation, resulting in shoreline recession at Linwood Beach.

Stanley Consultants also investigated other impacts of the Federal navigation structures on shoreline alignment and beaches, sediment budget, aesthetics, etc. Their analysis concluded that the offshore breakwater has contributed significantly to shoreline reorientation, characterized by accretion near the piers and erosion at eastern Linwood Beach. However, it has not been possible to quantitatively determine how much of the realignment was due to high lake levels, higher incidence of northeast winds or the offshore breakwater. They also concluded that only removal of the breakwater would be completely effective in returning the shoreline to the pre-1972 long-term equilibrium position, and any structure that reduces wave action to aid navigation also reduces the motive force which maintains shoreline equilibrium. The offshore breakwater has provided protection from high waves at the harbor mouth, and has had an adverse impact on shoreline reorientation and erosion at the east end of Linwood Beach. However, the apparent relative stabilization of the shoreline at its 1976 alignment leads to further conclude that no additional significant erosion of the beach is likely, but minor short-term fluctuations in orientation continue to occur as a result of storms, and beach width varies with lake levels. The bluff may continue to erode when storms occur during high lake levels, even though the beach remains in a long-term equilibrium position. On this basis, Stanley Consultants concluded that . . . "assuming that the beach is acceptable as it presently exists, no further consideration of mitigation for beach erosion is required." Periodic monitoring of the beach was recommended so that any future unanticipated reorientation of the shoreline is promptly recorded.

Buffalo Districts Stage 2 Conclusions

The Stanley Consultants' report was reviewed by the Buffalo District Engineer and the Coastal Engineering Research Center at Fort Belvoir, Virginia. It

was found that the conclusions reached by Stanley Consultants are considered reasonable and equitable to all concerned parties, including the Federal Government. Based on Stanley's results, the District prepared preliminary designs, cost estimates, and benefit calculations for eight alternatives to restore the easterly beaches to their estimated prebreakwater condition. This analysis is presented in the Syllabus to Stanley Consultants' May 1978 Section 111 Report (See Attachment 5 of Appendix D). From this Stage 2 preliminary analysis, the District concluded that mitigation of the loss of beach at Linwood should be undertaken, even considering that the highest benefit-to-cost ratio was 0.83 for Alternative 2 and the benefits were primarily recreational benefits as opposed to shoreline damages prevented, which is the basis for Section 111 mitigation. The recommendations of Stage 2 were: (1) to undertake Stage 3 of the Detailed Project Report with the alternative for mitigation at Linwood Beach selected considering input presented at a public meeting to be held at a later date, and (2) the need for mitigation (downdrift) to be investigated in Stage 3. Since that time, further observation of the easterly beaches by Buffalo District staff indicates a gradual approach of the shoreline to the east of the harbor to its prebreakwater equilibrium state. Therefore, the District subsequently decided to reevaluate the shoreline condition to the east before reaching a final conclusion on the need for mitigation to the east. This reevaluation was performed for Buffalo District by Tetra Tech Inc. in 1980-1981 (see Appendix A for Tetra Tech's report).

Related Erosion Studies and Activities

a. Section 14 Study - In 1977, at the request of local officials, the District undertook a Section 14 reconnaissance study to determine the need for and viability of providing emergency protection for a sanitary sewer interceptor line along the bluff at Linwood Beach. The results of this study are presented in a 30 September 1977, (revised 12 June 1979) letter report, SUBJECT: Section 14 Reconnaissance Report for Elberta Beach and Linwood Park, Vermilion, OH (Appendix C, Exhibit C.3). The proposed plan was a rubblemound revetment which was opposed by the Linwood Park Cottage Owners Association, leasees of the land. For this reason, the city could not provide a letter of intent for the local assurances.

In the Section 14 Reconnaissance Report, the District Engineer noted that the Vermilion Harbor Section 111 study was addressing the erosion problem at Linwood Beach. Several of the alternative plans of improvement considered in Stage 2 of the Section 111 study (see Syllabus to Stanley's May 1978 report) would incorporate protection of the interceptor sewer. However, as shown later in this report, the District's conclusion of no mitigation of shoreline damages under Section 111 precluded providing additional improvements in the form of a protective beach to protect the interceptor sewer.

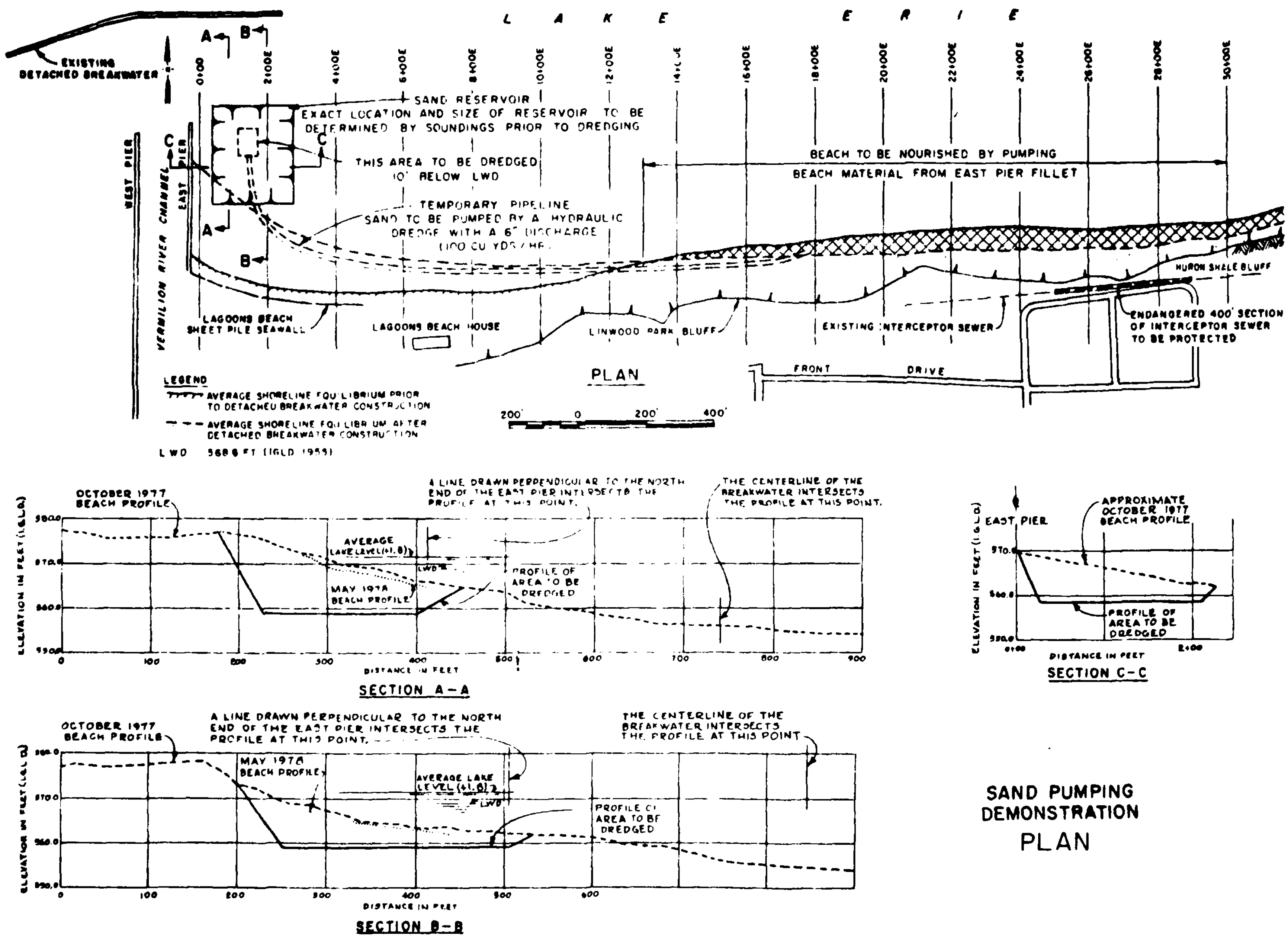
b. Sand Pumping Demonstration - In May 1979, the District performed a Sand Pumping Demonstration Program in Vermilion and subsequently published a report dated October 1980 (Appendix C, Exhibit C.2). The purposes of this Demonstration Program were: (1) to determine if the artificial transport of sand was a viable alternative for mitigation as suggested in the syllabus of the Vermilion Preliminary Section 111 Report, (2) to determine if

utilization of a hydraulic dredge produced and distributed by "Mud Cat" Division, National Car Rental Services, Inc., or similar equipment, could feasibly dredge and transport sand at Vermilion, OH, and other Federal recreational harbors.

The District performed preliminary lake bottom material surveys in 1977 and 1978 in order to locate a borrow area. Sand was to be pumped from the primary borrow source adjacent to the east pier at Lagoons Beach to Linwood Beach (Plate 4.1). Prior to the actual demonstration operation, the District made additional surveys and samplings of bottom materials in the vicinity of the proposed borrow source. Bottom sampling performed in April 1979 indicated that there was much less beach sand suitable in the proposed borrow area than anticipated. The northeasterly third of the proposed primary borrow source is predominantly silts and clay and not a suitable source for beach replenishment. On the basis of this information, the final limits of the primary and secondary borrow areas were established as shown on Plate 4.2. The sand pumping demonstration program actually began on 10 May 1979 and ceased on 19 May 1979. Based on an evaluation of the program, approximately 2,500 cubic yards of beach materials were pumped from Lagoons to Linwood Beach during 9 days of pumping operations. Productivity fell short of the 15,000 cubic yards planned to be dredged. The actual cost of the program was $41,000, producing unit cost of $16.40 per cubic yard.

Circumstances contributing to the poor performance and high unit cost of the demonstration program were numerous. However, considerable knowledge was gained with respect to artificially transferring sand with the use of hydraulic dredging equipment: the distance the Mud Cat had to pump material was too great for the type of material pumped. For the medium sand with gravel which was encountered at the project site, the maximum feasible pumping distance should have been about 1,500 feet. Since the medium sand with gravel was pumped approximately 3,000 feet under a 10-foot head, the pump could not deliver the sand with sufficient velocity at the discharge end. This caused the sand to settle in the pipe, and restrict the flow completely.

The Sand Pumping Demonstration Program at Vermilion was considered to be unsuccessful because only 17 percent (2,500 cy) of the desired volume (15,000 cy) of beach materials was pumped from Lagoons Beach to Linwood Beach. As mentioned above, large sizes of materials encountered and susceptibility of Mud Cat operations to bad weather made it difficult to improve production.



SAND PUMPING
DEMONSTRATION
PLAN

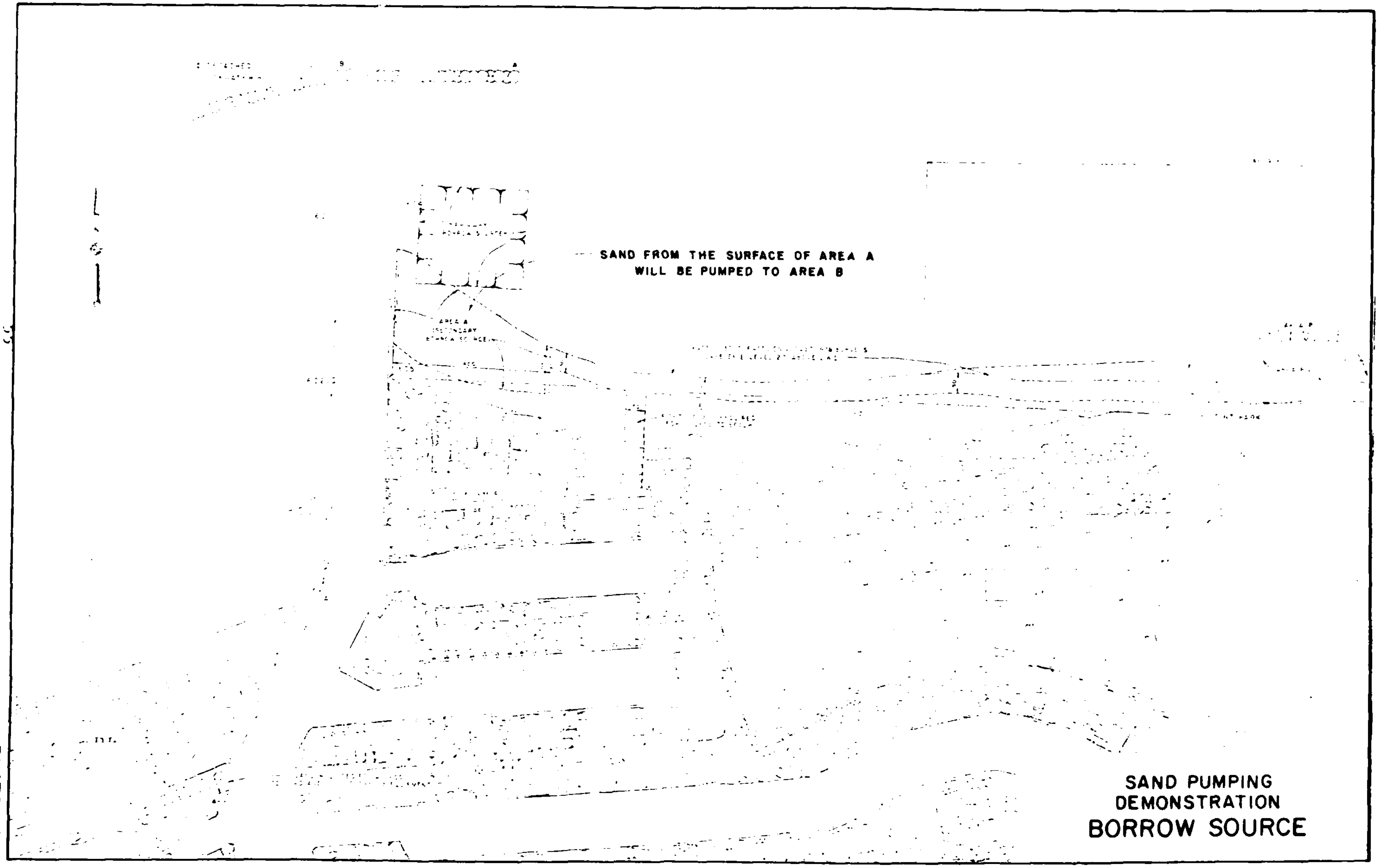

SAND FROM THE SURFACE OF AREA A
WILL BE PUMPED TO AREA B
SAND PUMPING
DEMONSTRATION
BORROW SOURCE

PLATE 4.2

SECTION V

SECTION 111 , STAGE 3 STUDIES

STUDY OF SHORELINE DAMAGES TO THE WEST OF VERMILION HARBOR

a. Introduction - In the summer of 1979, the District contracted with Tetra Tech, Inc. to study and define the impacts of the Federal navigation works at Vermilion Harbor, Ohio, on the shoreline to the west of the harbor structures. They (Tetra Tech) have made an extensive study of the shore processes, shore and beach characteristics, and of the physical forces involved such as waves, winds, currents, ice, and lake water levels. (Tetra Tech's July 1980 report is included as Appendix B to this report). They concluded that the fortification of these shores by private interests has masked the damaging effects of sediment blockage and diversion at the east harbors piers. In addition, the armored nature of the western shoreline makes the impact of the offshore breakwater indistinguishable from the impact of the harbor piers alone. In unprotected areas, further to the west, bluff erosion had been aggravated by the harbor piers and the subsequent armoring of adjacent shores. In these unprotected regions, 29 percent of the long-term bluff erosion rate is directly attributable to the Federal navigation structures at Vermilion.

Four alternative plans were evaluated for mitigation of these losses. These plans vary widely in structure, cost, and impacts on adjacent shores. They called for beach nourishment with structural protection, and bluff revetment. In addition, a "no-action" alternative plan has been considered. Due to relatively high construction costs and low derived benefits, none of these alternatives were economically feasible. These alternative plans are described below.

b. Description of Alternatives

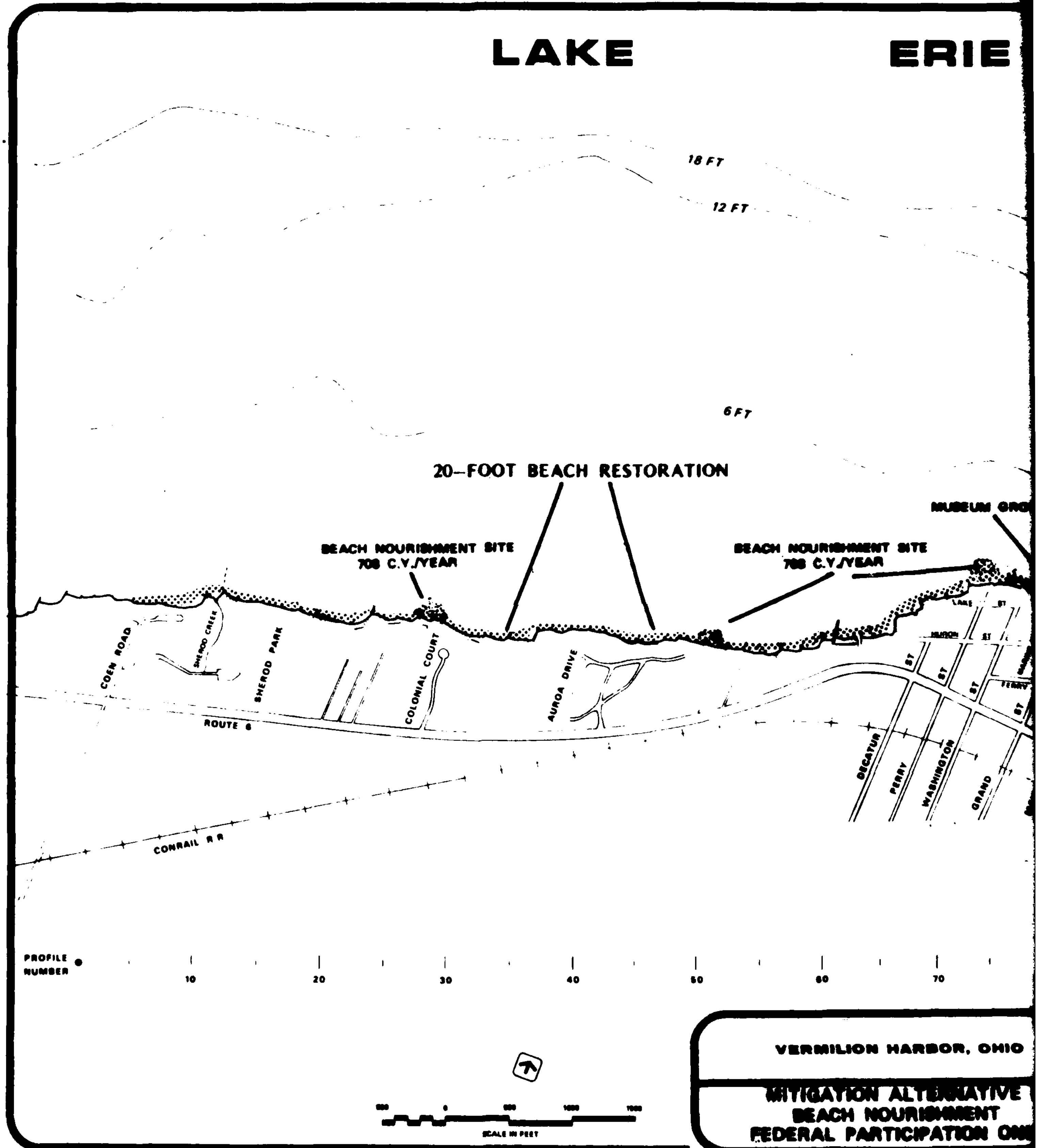
(1) Alternative 1 - Beach Nourishment. For Alternative 1 physical features, see Figure 5.1. This plan presents the maximum Federal responsibility. The elements include:

(a) 20-foot wide beach restoration (except 500 feet west of west pier).

(b) Beach replenishment at three sites (708 cy/year each).

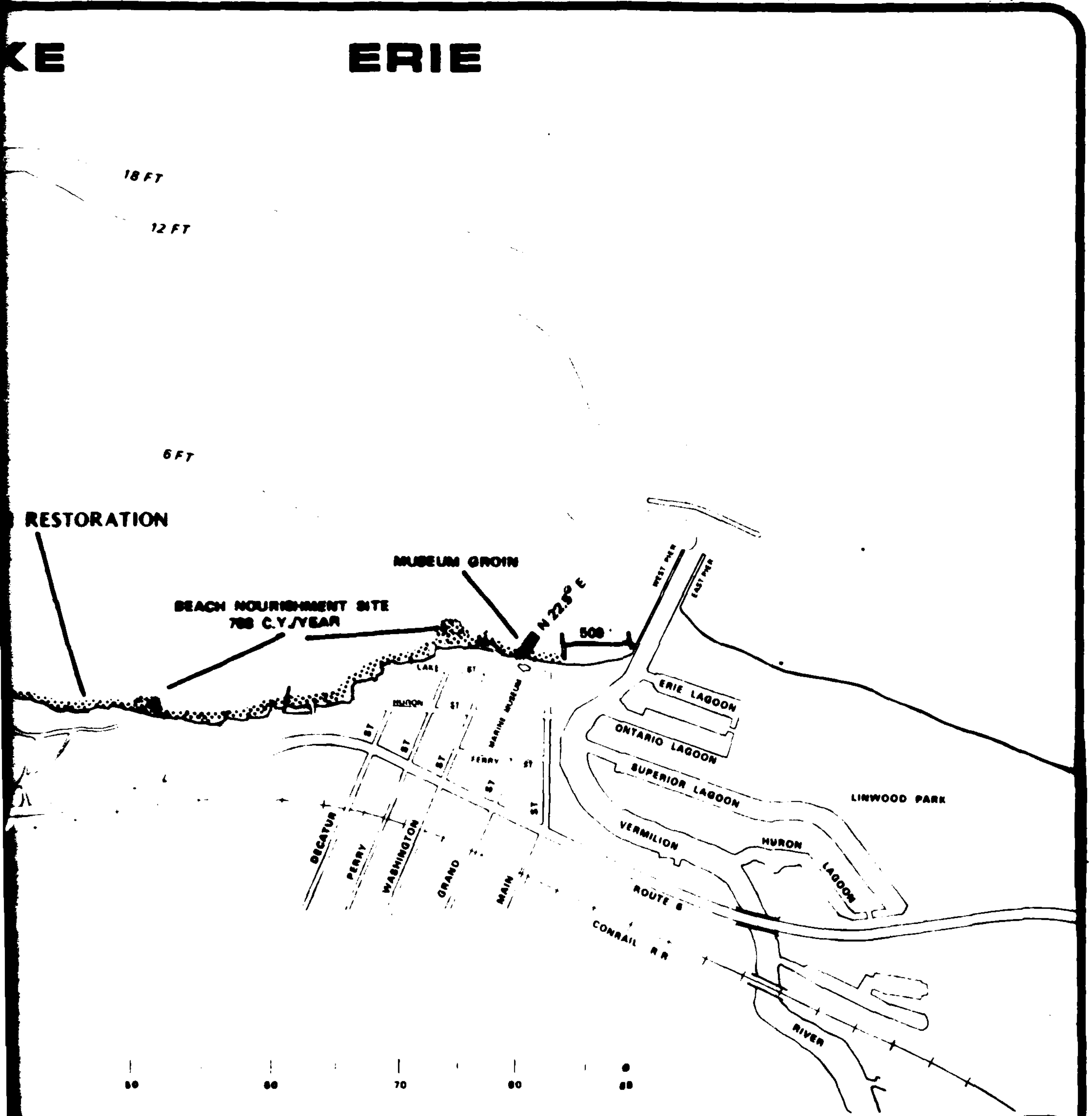
(c) Construction of 210-foot groin at Marine Museum to restrict eastward movement of beach sand into lee of harbor structures.

The first cost of Alternative 1 is estimated to be $283,300 (see Table 5, pp. 6-7 of Appendix B for detailed cost).



VERMILION HARBOR, OHIO

MITIGATION ALTERNATIVE
BEACH NOURISHMENT
FEDERAL PARTICIPATION ONL



VERMILION HARBOR, OHIO

MITIGATION ALTERNATIVE I
BEACH NOURISHMENT
FEDERAL PARTICIPATION ONLY

TETRA TECH
Pasadena, California

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Approved By:	P.G.	
Date:	12/1/79	of

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FIGURE 5.1

(2) Alternative 2 - Beach Nourishment. The features of Alternative 2 are shown in Figure 5.2. This plan supplements the maximum Federal effort with local participation that will result in the optimum beach nourishment plan.

(a) 20-foot wide beach restoration (except 500 feet adjacent to west pier).

(b) Beach replenishment at three sites (2,461 cy/year each). The Federal Government would be responsible for 29 percent (2,123 cy) of the cost of this item.

(c) Construction of a 210-foot groin at Marine Museum.

The beach nourishment program called for in this plan would require placement of 7,384 cy/year in three equal parcels at the 3 stations (29, 52, and 74). The first cost of Alternative 2 is $283,300 (see Table 6, pp. 6-11 of Appendix B).

(3) Alternative 3 - Beach Nourishment and Groin Construction. This alternative provides for the construction of a number of short groins that will serve as impoundment structures and thereby restrict the passage of the beach sand out of each "groin-bounded" shore compartment. The basic elements of this plan include:

(a) 20-foot wide beach restoration (except 500 feet adjacent to west pier).

(b) Beach replenishment at three sites (1,231 cy/year each). The Federal Government would be responsible for 57 percent (=2,123 cy) of the cost of this item.

(c) Construction of a 210-foot groin at the Marine Museum.

(d) Construction of 11 short (83-feet long) groins.

Figure 5.3 shows the location of these groins and the proposed nourishment site along with other features of this plan. The first cost of Alternative 3 is $461,930 (see Table 7, pp. 6-14 of Appendix B for detailed cost estimate).

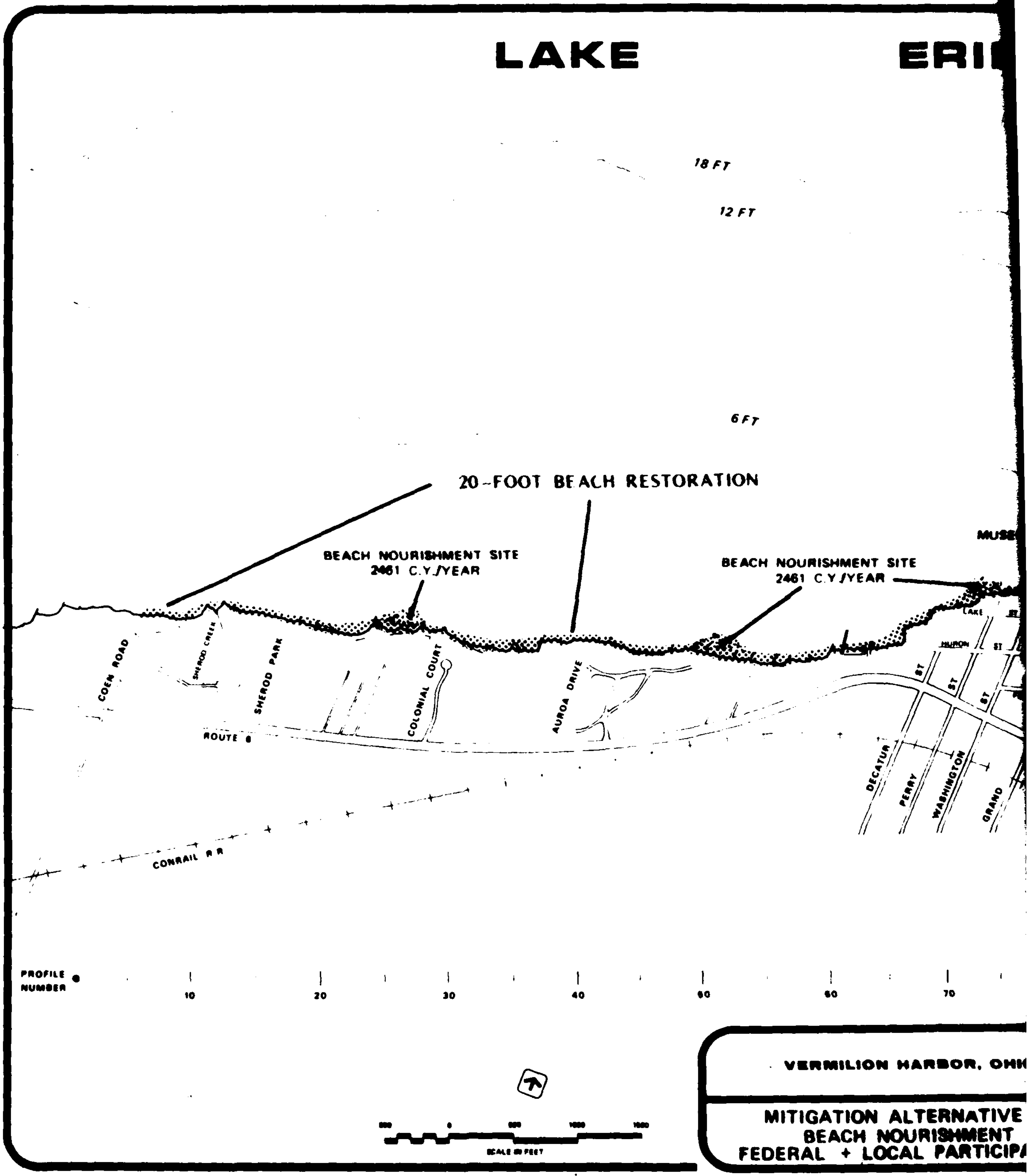
(4) Alternative 4 - Bluff Revetment. This plan calls for the total fortification of the bluff using a quarrystone revetment. This will serve to halt future bluff erosion. The major elements of this plan are:

(a) 20-foot beach restoration (360-foot long Vermilion City Beach only).

(b) Construction of 210-foot groin at Marine Museum.

(c) Construction of quarrystone revetment - Museum to Coen Road.

For physical features of this plan, see Figure 5.4. The first cost for Alternative 4 is $4,038,700 (see Table 8, pp. 6-17 of Appendix B for detailed cost estimate).



LAKE
ERI
18 FT
12 FT
6 FT
20-FOOT BEACH RESTORATION
BEACH NOURISHMENT SITE
2461 C.Y./YEAR
BEACH NOURISHMENT SITE
2461 C.Y./YEAR
COEN ROAD
SHEROD CREEK
SHEROD PARK
COLONIAL COURT
AUROA DRIVE
ROUTE 6
CONRAIL R R
LAKE ST
HURON ST
DECATUR
PERRY
WASHINGTON
GRAND
PROFILE NUMBER
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SCALE IN FEET
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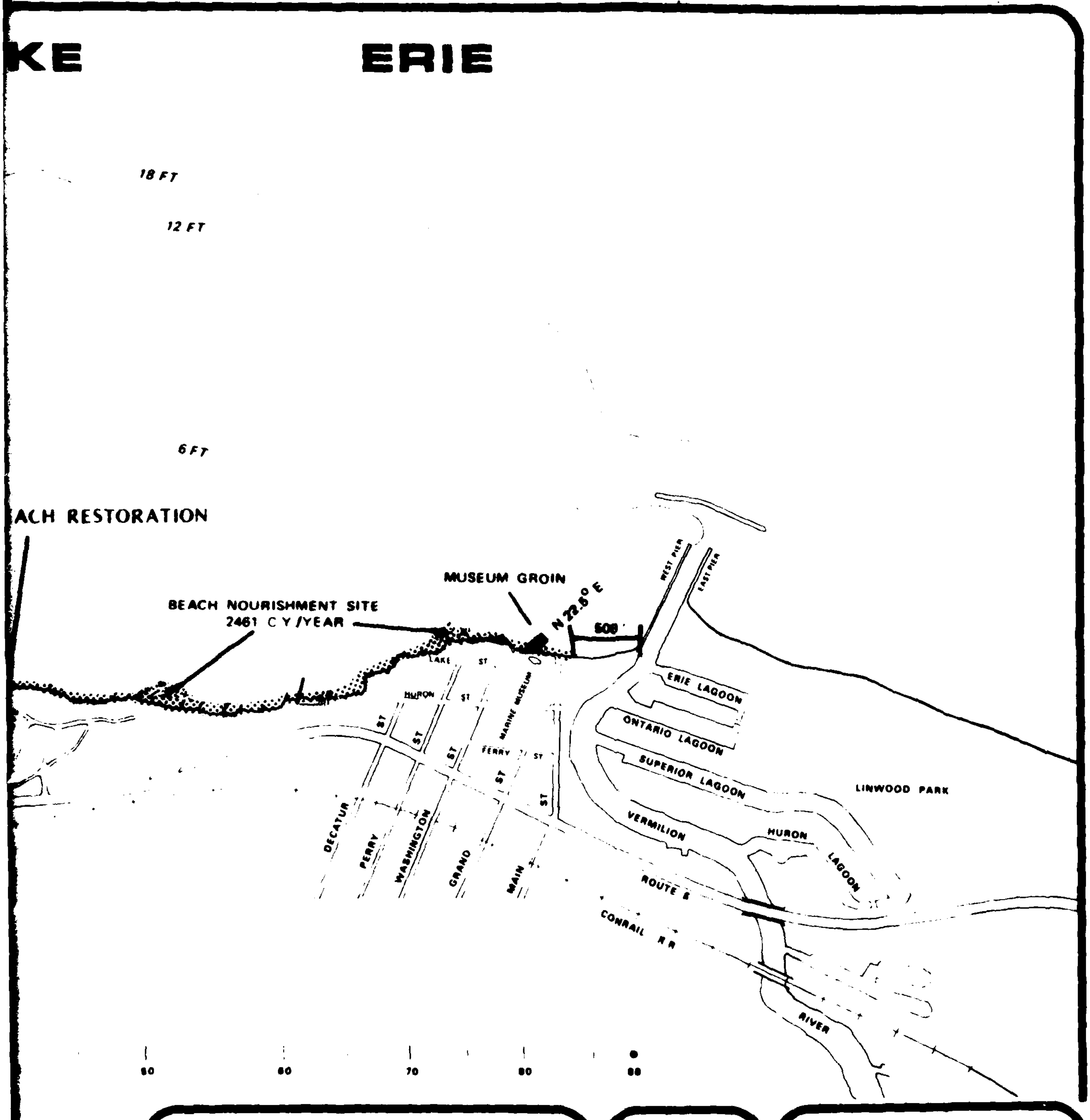
BEACH NOURISHMENT
FEDERAL + LOCAL PARTICIPA



VERMILION HARBOR, OHIO

MITIGATION ALTERNATIVE II
BEACH NOURISHMENT
FEDERAL + LOCAL PARTICIPATION

TETRA TECH
Pasadena, California

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Date:	12/1/79	of

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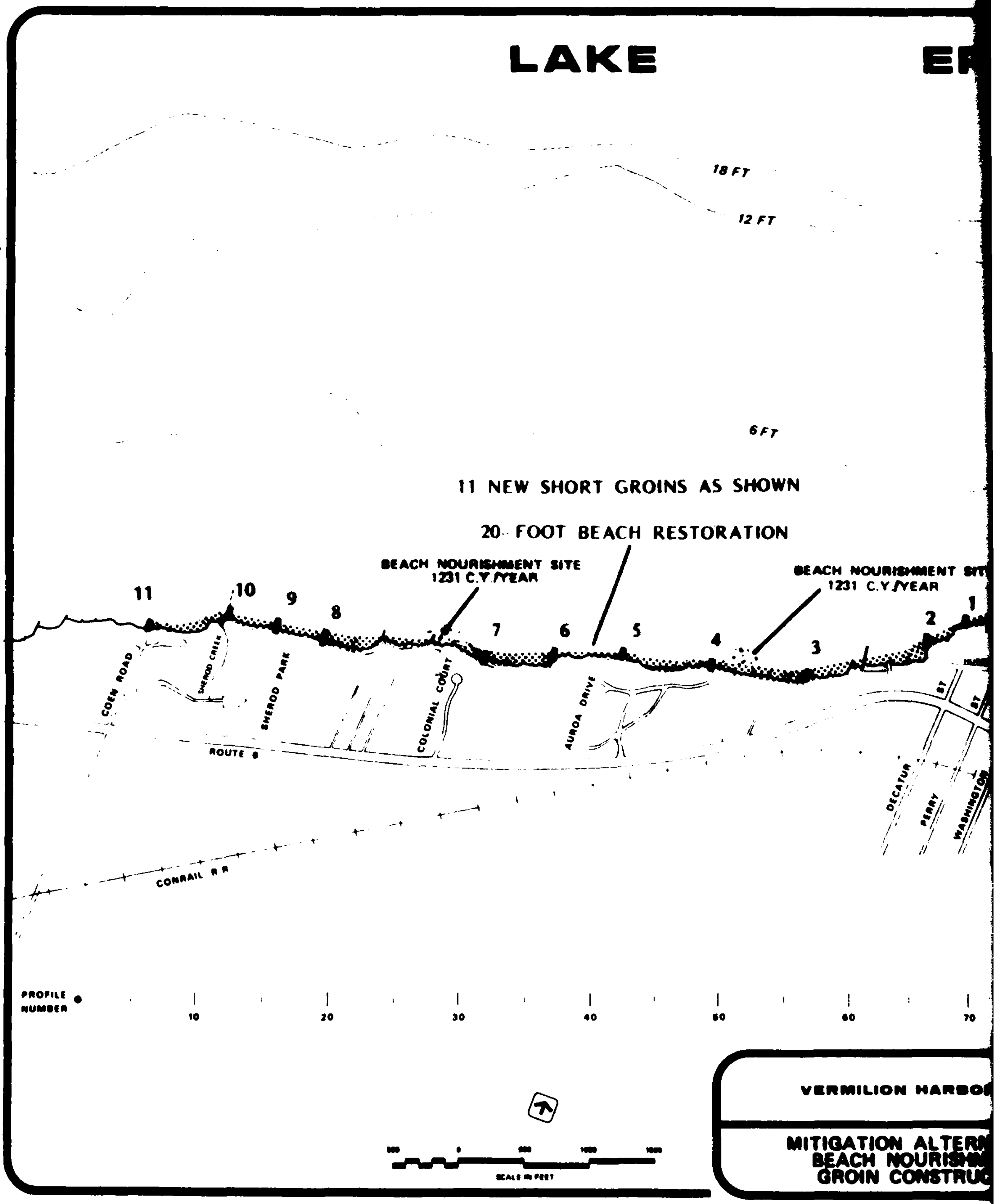
FIGURE 5.2



LAKE
ER
18 FT
12 FT
6 FT
11 NEW SHORT GROINS AS SHOWN
20 FOOT BEACH RESTORATION
BEACH NOURISHMENT SITE
1231 C.Y./YEAR
BEACH NOURISHMENT SIT
1231 C.Y./YEAR
11
10
9
8
7
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COEN ROAD
SHEROD CREEK
SHEROD PARK
COLONIAL COURT
AUROA DRIVE
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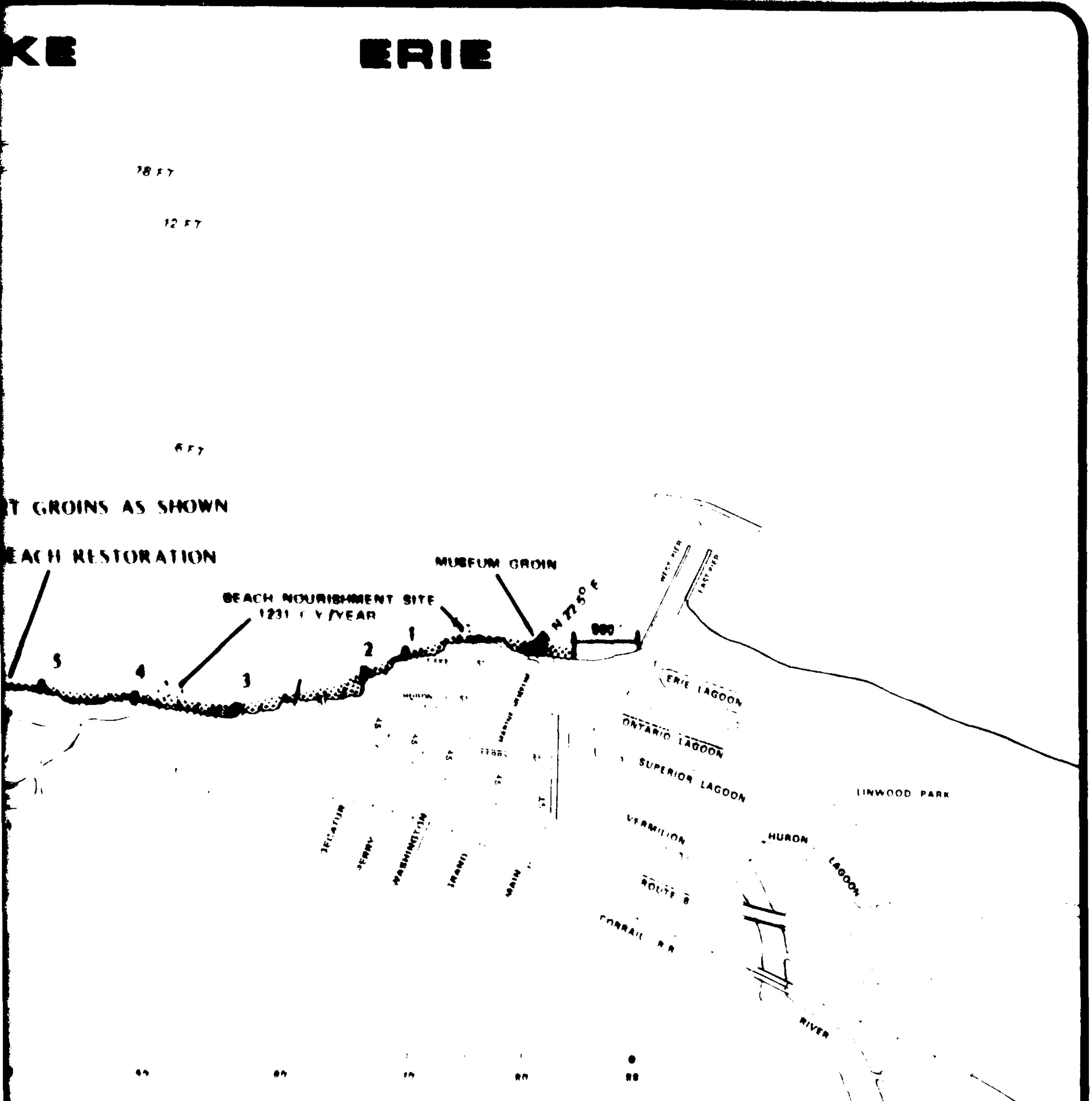

VERMILION HARBOR, OHIO

MITIGATION ALTERNATIVE III
BEACH NOURISHMENT +
GROIN CONSTRUCTION

TETRA TECH
Pasadena, California

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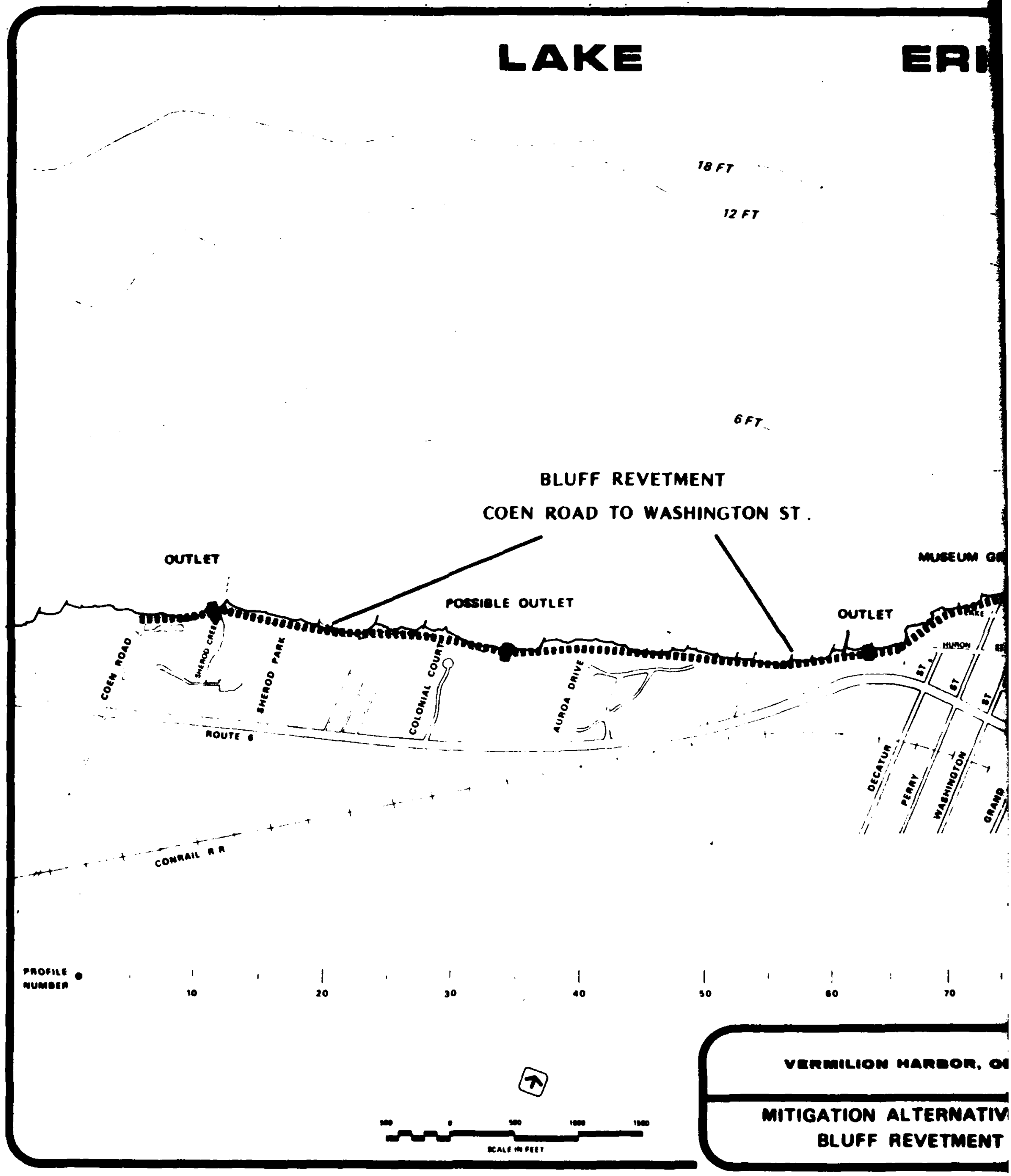
FIGURE 8.3


LAKE ERI
18 FT
12 FT
6 FT
BLUFF REVETMENT
COEN ROAD TO WASHINGTON ST.
OUTLET
POSSIBLE OUTLET
OUTLET
MUSEUM G
COEN ROAD
SHEROD CREEK
SHEROD PARK
COLONIAL COURT
AUROA DRIVE
ROUTE 6
CONRAIL R R
HURON
DECATUR
PERRY
WASHINGTON
GRAND
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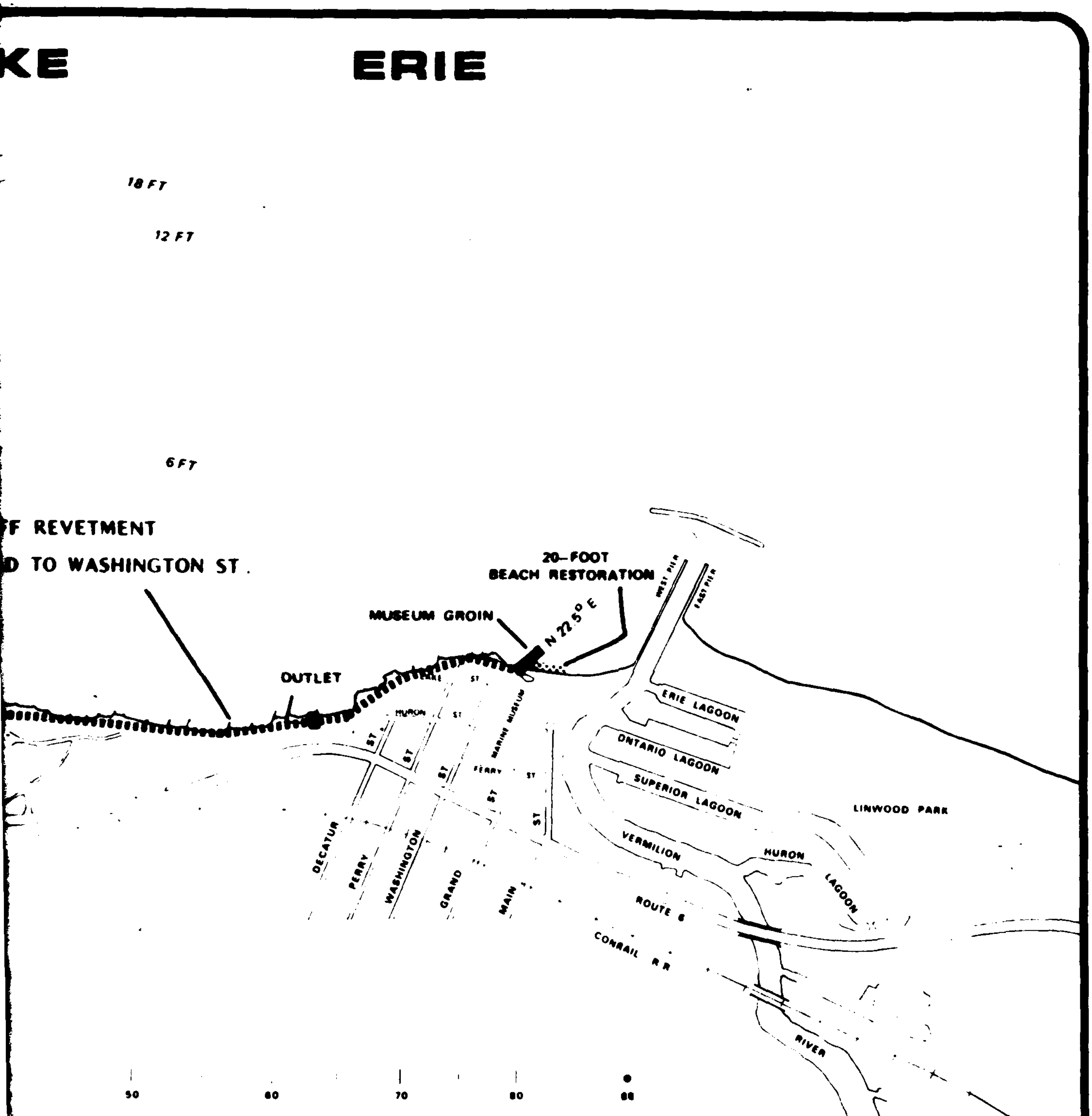
BLUFF REVETMENT



VERMILION HARBOR, OHIO

MITIGATION ALTERNATIVE IV
BLUFF REVETMENT

TETRA TECH
Pasadena, California

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FIGURE 5.4

c. Estimated Shoreline Damages - It was determined that there are four categories of shoreline damages attributable to the Vermilion Harbor structure. These categories are: loss of recreational use at City Beach; loss of public lands at Sherod Park; loss of residential lands; and loss of structures. As shown in Table 5.1 below, the total average annual loss (damage) to the west of Vermilion Harbor is estimated at $22,770, annually. Of this total, $5,750 are attributable to the Vermilion Harbor structures and $17,015 are naturally induced, as shown in Table 5.3. The derivation of these values are discussed in Attachment 1 (Buffalo District's Economic Reevaluation) to Appendix B.

Table 5.1 - Total Expected Annual Losses West of Vermilion Harbor (Base Year 1982)

	Annual Land Loss (sq. ft.)	Total Loss to 2035 (sq. ft.)	Average Annual Loss (1) ($)
Loss of Recreational Usage Vermilion City Beach	60	3,000	1,009
Loss of Public Land Sherod Park	1,890	94,500	4,253
Loss of Residential Land	4,190	209,500	9,428
Loss of Structures	-	six structures	8,076
Total	6,140	307,000	22,770 (2)

(1) July 1980 price levels; 7-1/8 percent interest rate.

(2) Rounded up to nearest 10.

SOURCE: For discussion of these damages, see Buffalo District's Economic Reevaluation, Attachment 1 to Appendix B (Tetra Tech 1980 Report).

d. Benefit Evaluation and Economic Analysis - Residual average annual damages to the west of the harbor for the four mitigation plans investigated were obtained. These residual damages are discussed in Attachment 1 to Appendix B and summarized in Table 5.4, below. Table 5.4 shows that residual annual damages would be $5,200 for Alternative 1 and all damages would be eliminated for Alternatives 2 through 4.

Average annual benefits for all plans of improvement considered consist of (1) shoreline damages prevented; and (2) the annual equivalent of the recreational value added due to additional beach area added. The derivation of these average annual benefits is discussed in detail in Attachment 1 to Appendix B (Tetra Tech 1980 Report), and summarized in Table 5.5 below. As

shown in Table 5.5 the estimated annual benefits to the west of the harbor structures vary from a minimum of $23,340 for Alternative 1 to a maximum of $30,750 for Alternatives 2 and 3.

Table 5.2 - Inventory of Stickout Structures (1), Vermilion Reach

Location	Structure Number (1)	Type and Number of Structures (2) 1877	1937	1973
Lorain-Erie County Line	1a	-	G	-
	1b	-	G	-
	3	x	x	2J
	4a	y	G	-
	4b	-	G	-
	5	y	x	G
	6a	-	G	-
	7	-	-	2G
	8	-	G	-
	9	-	y	3G
	10	y	x	G
	10a	-	G	-
	11	-	x	G
	12	G	x	3G/B
	13	-	G	2G
	13a	-	G	-
	14	-	y	G
	15	-	G	3G
	16	-	2G	G
	17	-	x	2G
	18	-	-	3G
	19	-	G	G
	19a	-	G	-
	20	-	GF-4	GF-7

(1) Structure numbers correspond to numbers in aerial photos 5.1-5.4a. Only structures visible on maps and aerial photographs (stickout structures) are included in this table. Photos 5.1-5.4 show location of structures in the vicinity of the harbor.

(2) B, breakwater; G, groin; GF, groin field; J, jetty; P, pier, x, structure identified in later year is most likely the same structure observed on map or aerial photograph; y, structure identified in later year is possibly the same structure observed on map or aerial photograph; for structure numbers which include more than one structure, the number of individual structures is given.

Table 5.6 presents a summary of annual costs, annual benefits and the benefit/cost ratios for the four alternative plans of improvement considered for mitigating shoreline damages to the west of the harbor structures. From this summary, it is seen that Alternative 1, having a benefit-to-cost ratio of 0.51, would be the most economically efficient of all the plans considered.

Table 5.3 - Percent of Federally and Naturally-Induced Damages

Category	Annual Damages	Total Federally Induced	Naturally Induced	Percent Federal	Percent Natural
	$	$	$		
Structure Damages	8,076 (1)	1,729 (1)	6,347 (1)	21	79
Residential Damages	9,428 (2)	2,694 (2)	6,734 (2)	29	71
Public Land Loss	4,253 (3)	1,215 (3)	3,038 (3)	29	71
Recreation Beach Loss	1,009	113	896 (4)	11	89
Total	$22,770	$5,750	$17,015	25 (5)	75

(1) See Attachment 1, Economic Reevaluation (pp 1 of 16)
(2) See Attachment 1, Economic Reevaluation (pp 4 of 16)
(3) See Attachment 1, Economic Reevaluation (pp 4 of 16)
(4) See Attachment 1, Economic Reevaluation (pp 1 of 16.a)
(5) See Attachment 1, Economic Reevaluation (pp 1 of 16.a)

SOURCE: Attachment 1, Economic Reevaluation (pp 1 of 16; 4 of 16; 1 of 16.a), Supplement to Appendix B, Tetra Tech, 1980 Report.

Table 5.4 - Average Annual Damage Summary for Shoreline to West of Harbor Structures

Alternative	Structures	Land Loss		Recreation	Residual Average Annual Damages
		Residential	Public	Existing	
	$	$	$	$	$
No Action	8,080	9,430	4,250	1,010	22,770
Alternative 1	2,980	1,530	690	0	5,200
Alternative 2	0	0	0	0	0
Alternative 3	0	0	0	0	0
Alternative 4	0	0	0	0	0

Table 5.5 - Average Annual Benefit Summary for Shoreline to West of Harbor Structures

Alternative	Total Damages Prevented	Total Recreation Benefits	Total Average Annual Benefits
	$	$	$
1	16,660	6,680	23,340
2	21,760	8,990	30,750
3	21,760	8,990	30,750
4	21,760	2,560	24,320

e. Summary Evaluation of Mitigation for Shoreline Damages to the West of the Harbor Stuctures - None of the four alternative plans described above has been identified as an economically feasible erosion mitigation alternative as shown in Table 5.6. The actual benefits attributed to beach and bluff protection are relatively small. Currently, the total annual damages due to losses of residential and public land, and structures; and to loss of recreational resources along the study reach were estimated to be approximately $22,700 (Table 5.4). In terms of erosion mitigation under Section 111 Authority, only the value of the erosion induced by the Federal navigation structure can be considered in the economics of the mitigation alternatives. Thus, $5,750 or 25± percent of the total annual damages (Table 5.3) would be the total annual damage attributable to the harbor structures, which will occur in the future if no action is taken.

Furthermore, comparison of the pre vs. postbreakwater aerial photographs indicate that the offshore breakwater has caused no increased detrimental effect on the shoreline which lies to the west of the harbor. Because of private protective works (see Table 5.2) built in those shore areas just west of the west piers, no significant erosion damage has been recorded in recent years in most sections of that shoreline. As summarized in the Tetra Tech 1980 Report:

> "In the brief period since the construction of the offshore detached breakwater, no net effect of this new navigation work can be surmised. Local effects of this breakwater are apparent due to its "shadow" effect for waves from the northeast. These, however, are limited to a redistribution of beach material in the Marine Museum/City Beach area causing a sand fillet to develop adjacent to the west pier. The offshore breakwater has had such a limited effect on the shoreline west of Vermilion Harbor mainly because its sole influence has been to further limit or stop the already minute amount of littoral material bypassing the existing harbor piers."

Table 5.6 - Economic Analysis Summary for Shoreline to West of Harbor Stuctures

	Alternative 1	Alternative 2	Alternative 3	Alternative 4
	Beach Nourishment Minimum Federal Responsibility	Beach Nourishment Optimum Plan	Beach Nourishment Short Groins	Bluff Revetment
	$	$	$	$
Estimated First Costs (1)	283,300	283,300	461,930	4,038,700
Estimated Annual Costs				
Interest and Amortization (2)	20,850	20,850	34,000	297,300
Annual Maintenance	3,550	3,550	14,300	200,700
Beach Nourishment	21,230	73,840	21,230	0
Total	45,630	98,200	85,200	498,000
Estimated Annual Benefits	23,340	30,750	30,750	24,320
Benefit/Cost Ratio	0.51	0.31	0.36	.05

(1) 1980 price levels.

(2) 7-1/8 percent interest, 50-year project life.

Due to early shore protection measures constructed by private land owners in Vermilion, much of the shoreline along the study reach is relatively well fortified and therefore resistant to erosion-induced damage (stickout structures are shown in Photos 5.1-5.4.a). Further observations by the District have not revealed otherwise.

REASSESSMENT OF THE NEED FOR MITIGATION OF SHORELINE DAMAGE EAST OF THE HARBOR STRUCTURES

a. Introduction - Subsequent to completion of the Stage 2 Section 111 Study by Stanley Consultants in 1978, certain events have occurred that caused the District to reassess its position concerning mitigation of shoreline damages to the east of the harbor structures. Periodic observations of the easterly beaches indicated that significant accretion was occurring at Linwood and Nakomis Beaches. A clear observation was that the reoriented shoreline has not stabilized as suggested by Stanley Consultants in the May 1978 Stage 2 Report. The District evaluation was that, in the long-term, the easterly shoreline will assume an orientation similar to that existing prior to construction of the breakwater in 1973. The "shadowing effect" of the breakwater which prevents some longshore transport from Lagoons Beach easterly onto Linwood and Nakomis Beaches during storms from the northwest, is minimized by the lakeward migration of the shoreline at the East Pier Fillet, inducing a similar lakeward migration of the shore further to the east. Photos 5.5 and 5.5.a for instance exhibit significant accretion in the pocket at Nakomis and at the east end of Linwood Beach. Because of these new trends, the District conducted bathymetric surveys of the easterly beaches in June 1979 and August 1980 and subsequently modified Tetra Tech contract in October 1980 to include a reevaluation of these beaches to reflect pre and postbreakwater conditions. In July 1981, Tetra Tech completed its final report (herein included as Appendix A) titled: Summary Evaluation, Historical Shore and Bluff Changes East of Vermilion Harbor, Ohio.

b. Methodology Used by Tetra Tech - The basic methodology used to quantify beach area changes and bluffline changes for the pre and postbreakwater conditions east of the Vermilion Harbor piers, was analysis of historical shoreline changes using available maps, compute supported aerial photo analysis techniques and bathymetric surveys.

The aerial photo analysis has updated the previous analyses providing more comprehensive coverage of the pre and postbreakwater construction. Survey volume trends reported in an earlier study were compared with trends identified by aerial photo analysis to facilitate the documentation of historical changes of Lagoon, Linwood and Nakomis Beach system and provide a basis for determining the impact of the breakwater on shoreline configuration.

The aerial photo analysis performed in this study was undertaken for the reach encompassing Lagoons, Linwood and Nakomis Beaches. Aerial photos selected for additional analysis in this study were chosen to augment those in the earlier study especially around the critical period of construction of the breakwater in 1973 and 1974. Interpretation of aerial photography only represents the change with time, of the position of the line representing the interface of land with the lake. As such, this method does not take into

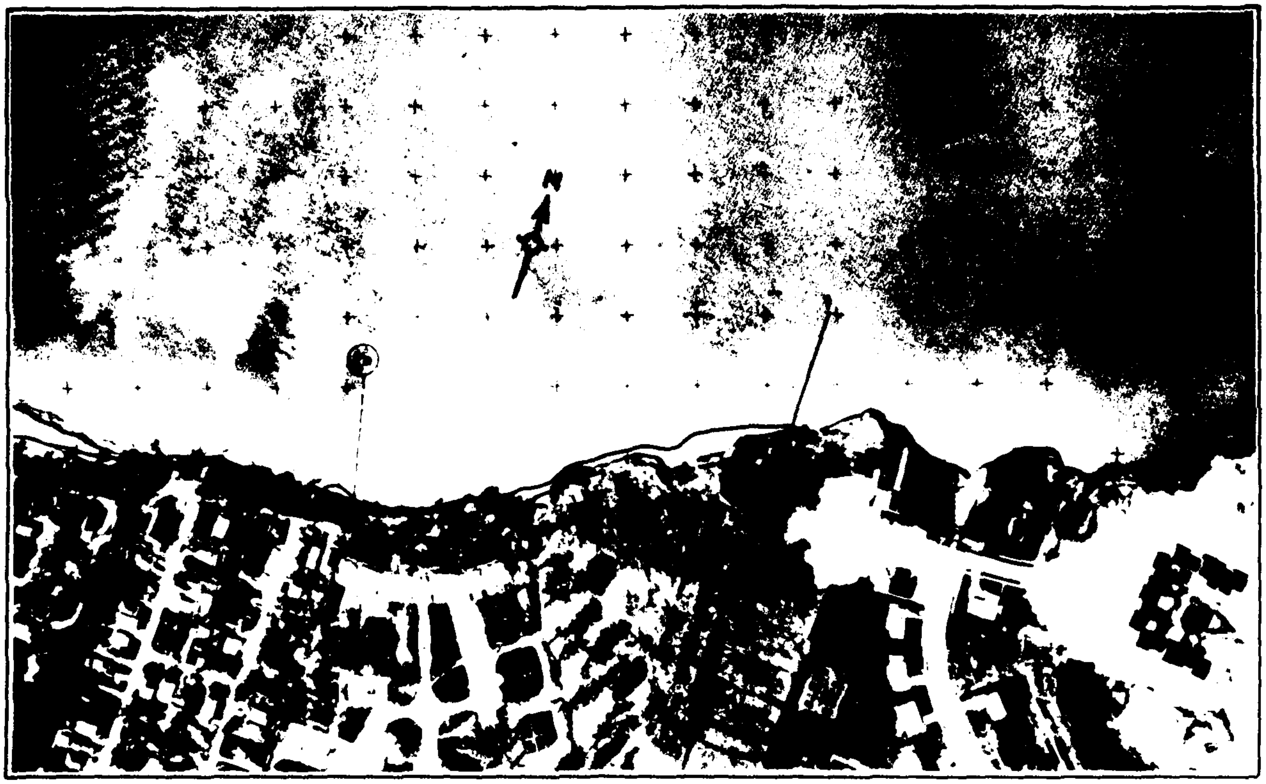


PHOTO 5.1

PHOTO 5.1a

NOTE: (1) RANGE LOCATION AND NUMBER OF STRUCTURE.
SEE TABLE 5.2 FOR DESCRIPTION.

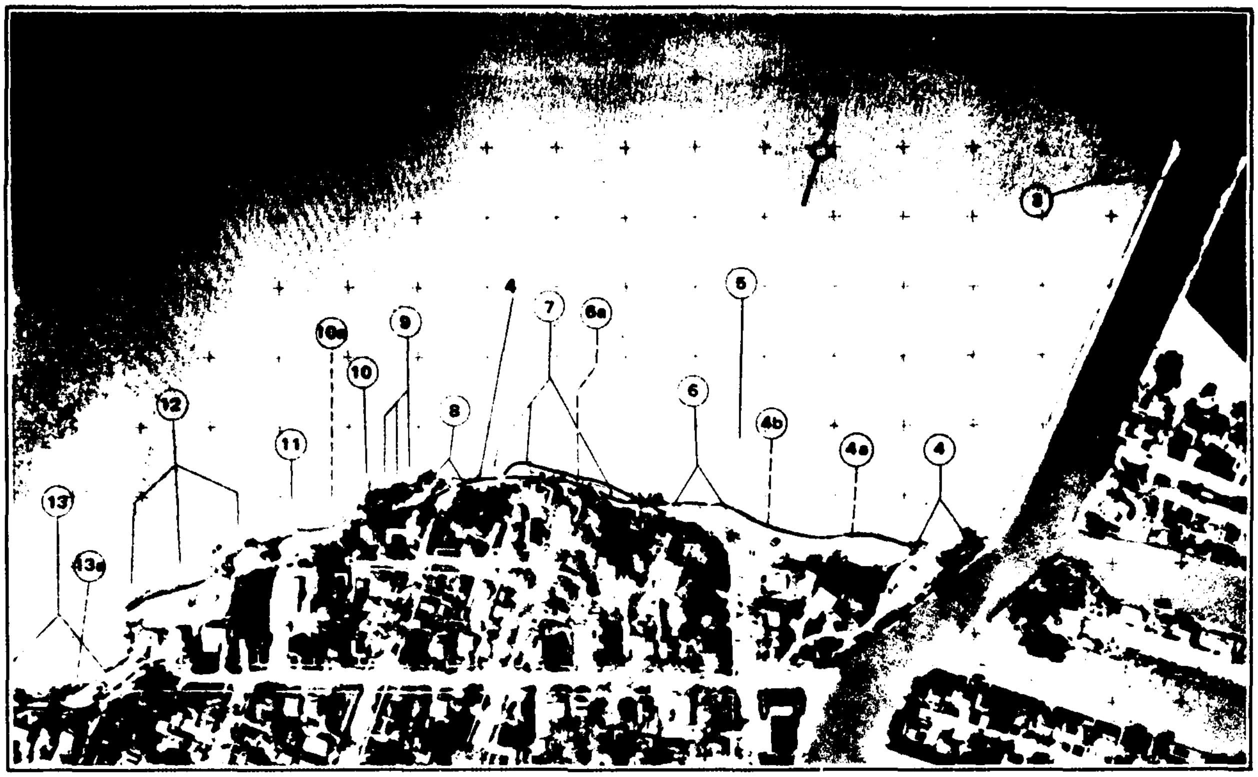


PHOTO 5.2

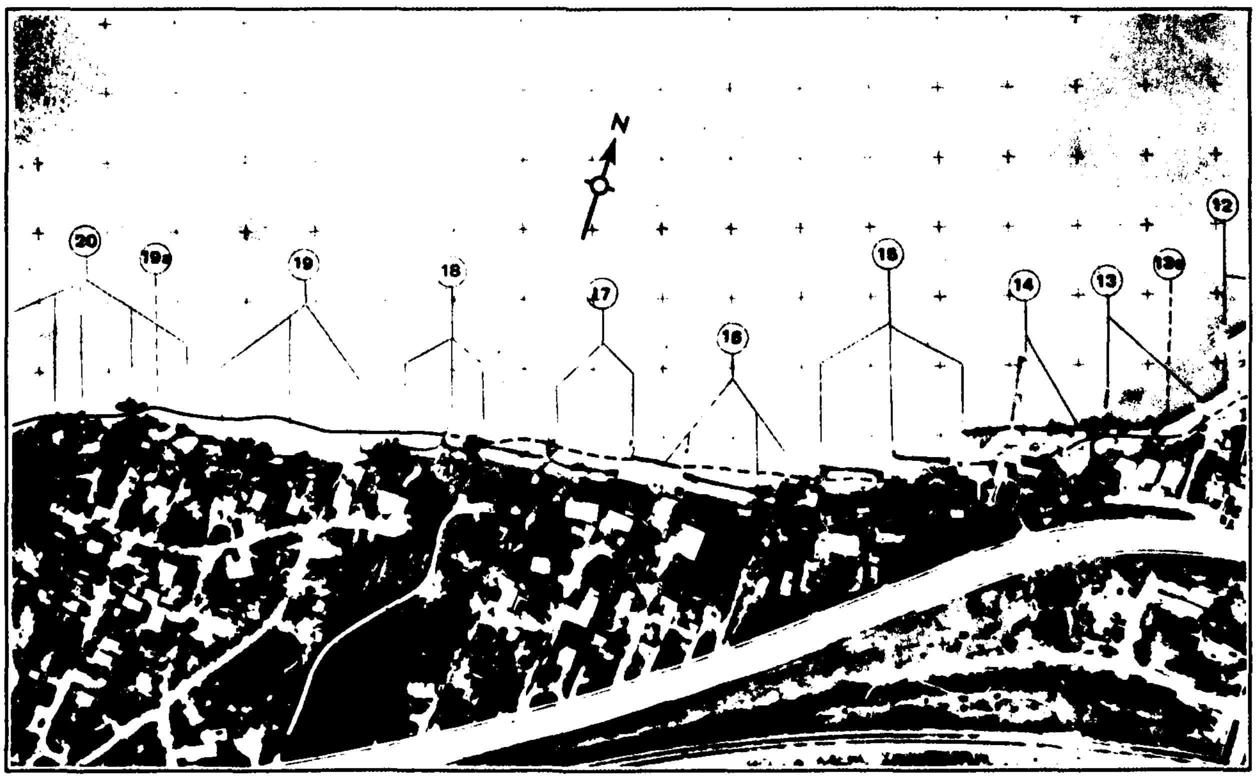


PHOTO 5.2a

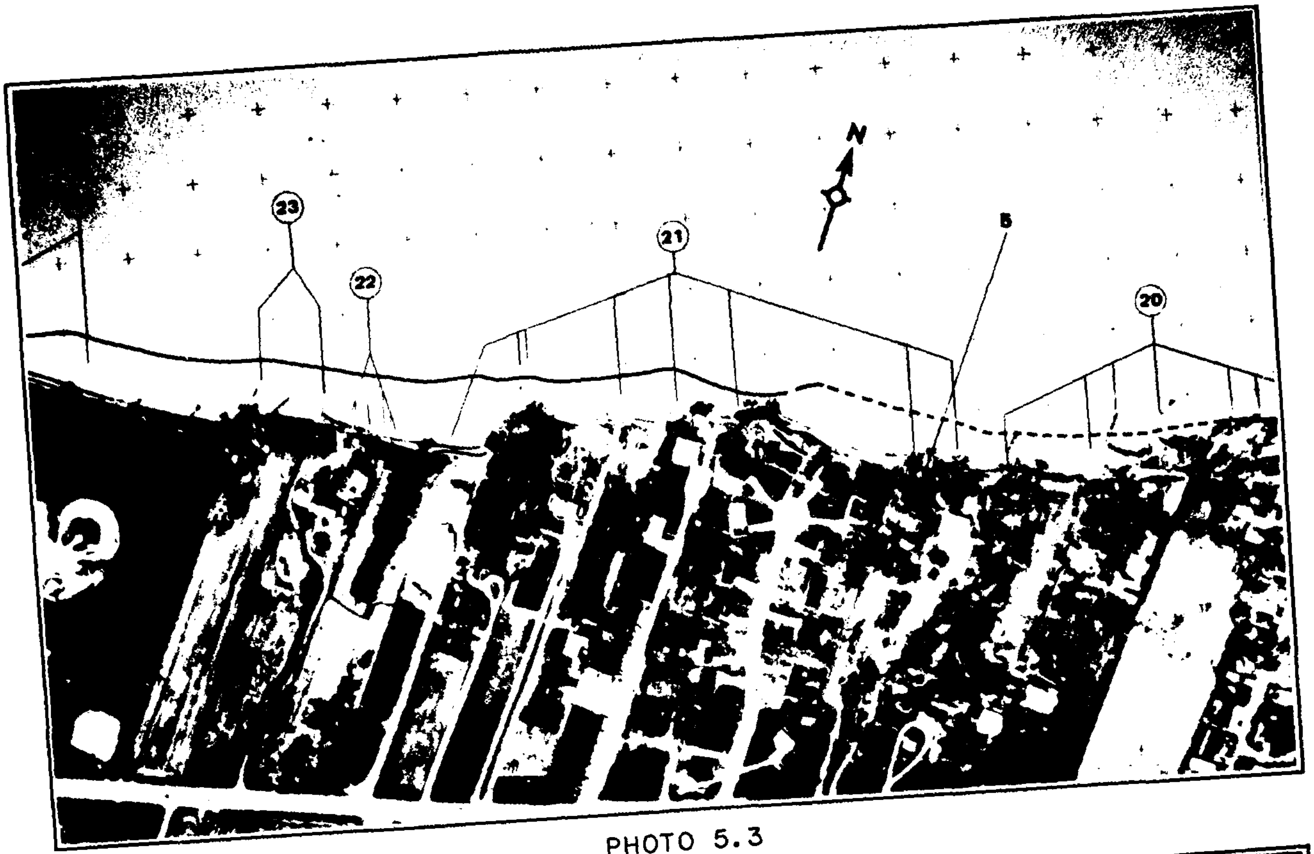


PHOTO 5.3

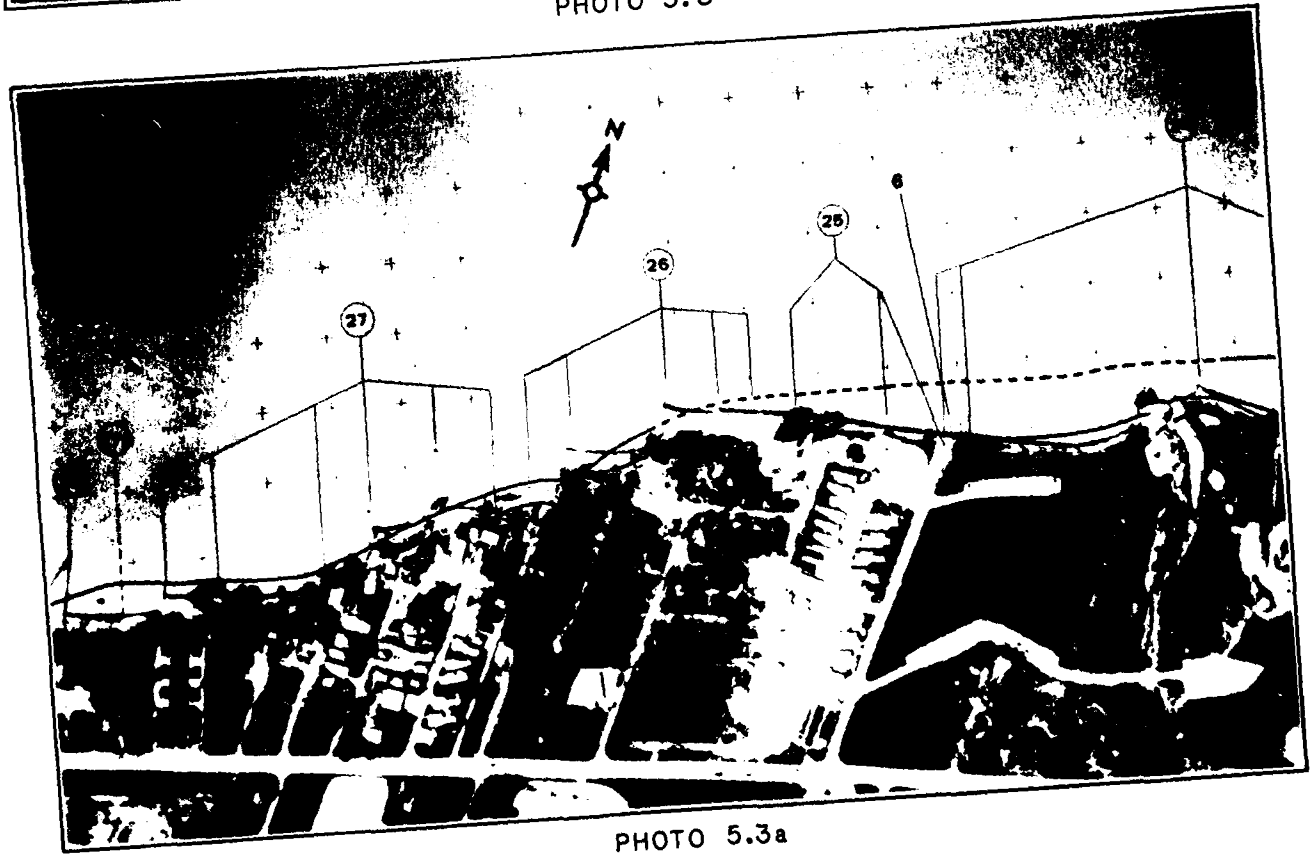


PHOTO 5.3a

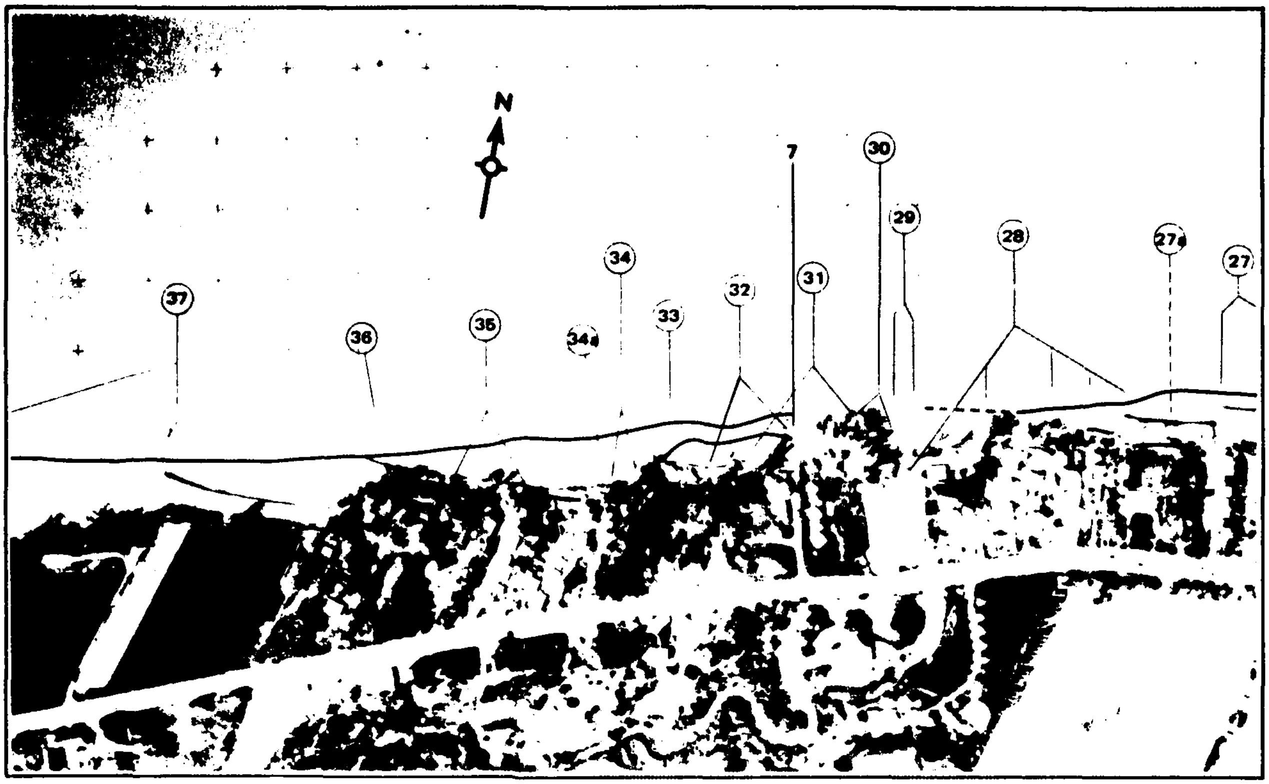


PHOTO 5.4

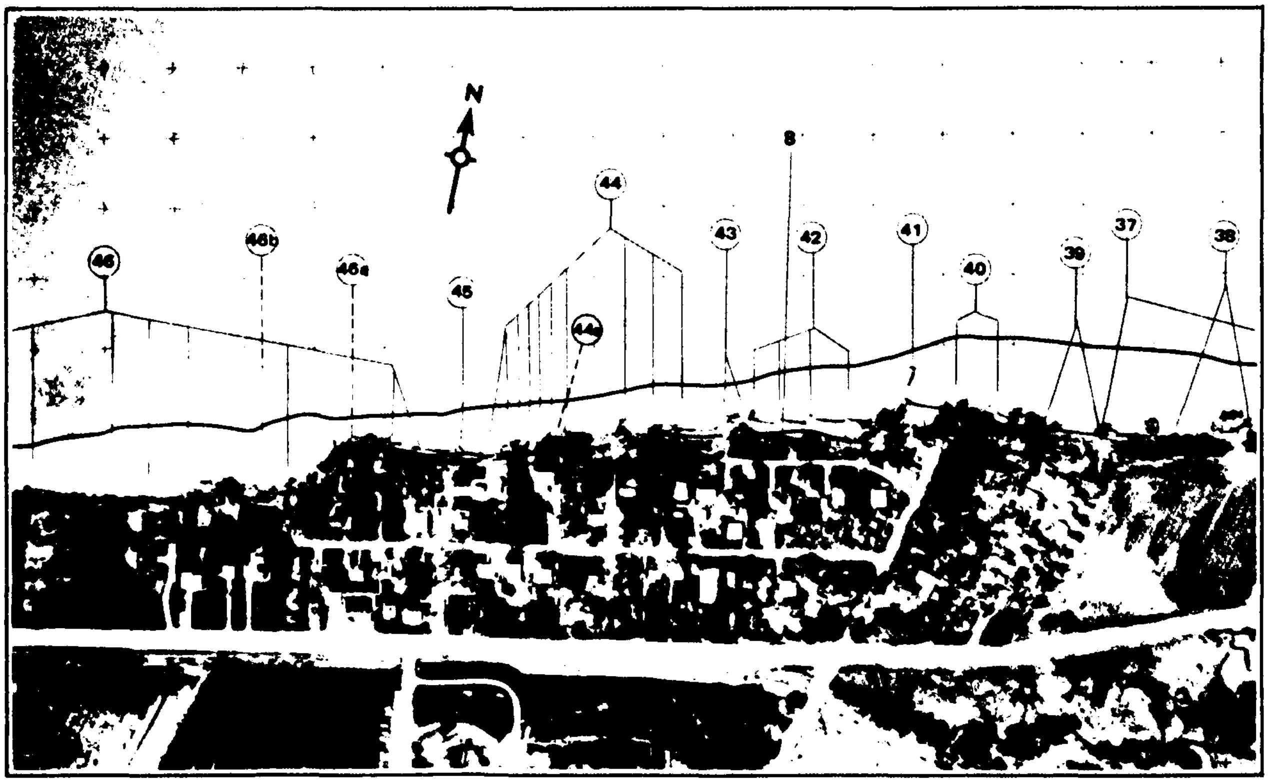


PHOTO 5.4a

account what happens above or below the waterline. Experience suggests that there should be a definite relationship between the movement of the shoreline and the amount of volume change coincident with recession or accretion. Experience also suggests that this relationship may not be the same for all cross-sections along the shoreline especially if they are oriented at different angles to wave incidence or composed of slightly different materials. The average end method was used to estimate the volume change in any particular shoreline segment. Figure 5.5 shows the combined 1977 to 1980 Corps data in a postbreakwater period in contrast to the Stanley 1974-1977 data just following breakwater construction. A comparison of the 6 years (1974-1980) since breakwater construction and the 5 years (1968-1973) prior to breakwater construction, shows that accretion trend adjacent to the East Pier has decreased to about half of the prebreakwater levels. Also, the extent of accretion along Lagoons Beach has decreased and the eastern segment of Lagoons Beach indicates an eroding trend. The eastern reach (Stations 18 through 28) which was eroding during the prebreakwater period now indicates accretion. However, any attempt to determine the effects of the breakwater on the shoreline based on volumetric change data alone would be inconclusive.

Volumetric shoreline change rate trends determined from bathymetric survey analysis were compared to the combined aerial photo data base. Very good agreement was found between the two types of data, indicating that the trends shown were a valid documentation of historical shoreline changes. The aerial photo coverage and field survey data show that for the Lagoons-Linwood-Nakomis segments the trend of the shoreline before breakwater construction was that of slight accretion for the Lagoons segment, minimal recession for Linwood and near zero recession for the Nakomis segment.

c. Evaluation of Short- and Long-Term Shoreline Changes Attributable to the Detached Breakwater

(1) Shoreline Changes. Major changes in beach configuration have taken place throughout the 1948-1980 study period. Along with the lake level, the total length of sandy beach has fluctuated. Temporary reversals in the direction of the littoral drift have caused lakeward and shoreward shoreline migration as revealed by the study of shoreline relative positions by Tetra Tech (Appendix A).

Figure 5.6 shows the shoreline relative positions with respect to Low Water Datum in the vicinity of the harbor structures for the 1835-1978 period as presented in the 1978 report prepared by Stanley Consultants. These relative positions have indicated a reorientation of the easterly shoreline in mid-1973 with a lakeward migration of that reach between the East Pier and Station 14+00E, and shoreward migration between Stations 14+00E and 30+00E. The September 1980 shoreline, recently plotted, show a moderate erosion from approximately Station 12+00E to Station 24+00E with respect to the 1973 shoreline. Some accretion occurred in the area between Station 24+00E to Station 30+00E indicating a lakeward migration of the shoreline. Figure 5.7 shows the locations of the 1948, 1973, and 1980 shorelines with respect to the harbor entrance structures and the chosen baseline. There is little net change indicated for the 1948-1973 period. Along Linwood Beach, erosion is evident on a continual basis from 1948 to 1980, except on the easternmost

PHOTO 5.5

Looking East toward Nakomis Beach from Linwood Beach, significant accretion occurred in Pocket at Nakomis and at East end of Linwood Beach. Berm width is about 60 ft. at sewer outfall. Photo taken April 1981.

PHOTO 5.5a

Looking West from Nakomis Beach, photo shows more accretion at Linwood Beach with about 60 foot wide berm at sewer outfall. Photo taken April 1981.

stretches of the beach where reversal is evident in the 1973-1980 period. Reversal of the erosional trend is evident on Nakomis where no beach was observed in 1973. Recent photographs taken at different time intervals and months in 1981 have shown near complete recovery of the beach from the East Pier to Nakomis Beach. Field measurements of beach widths taken along the entire shoreline shows a reorientation of the shoreline moving lakeward. Nakomis Beach, which was nonexistent in 1973, had a 40-foot berm fronted by 20-foot foreshore in May 1981. Lagoons Beach had an average berm width of 170 feet. The average berms along Linwood and Nakomis reaches were about 130 and 40 feet, respectively. Land-based photos also taken early in April 1981 shows that the shoreline reorientation process is continuing, characterizing a reversal from erosion to accretion.

Accretion of sand on the east side was one of the characteristics of the prebreakwater period. Long-term trends shown by the 1948-1973 curve (Figure 5.8) reveal small levels of accretion on the order of 1 foot per year along Lagoons Beach. During the 1973-1974 transition period of very high lake levels, rapid shoreline adjustment to the new structure became apparent as the beach morphology adjusted to that structure. Lagoons Beach, protected by the breakwater, grew as high lake levels and intense easterly storms drove sand toward the west and into the sheltered area behind the breakwater.

During the 1974-1980 period, as lake levels fluctuate, notable changes in beach configuration have taken place. The accretion trend adjacent to the East Pier has decreased to about one-half the prebreakwater levels. Reversal of erosional trend is evident on Linwood and more so on Nakomis where no beach was observed in 1973. Figure 5.8 shows the erosion and accretion rates which have occurred at each reach, along the shoreline throughout the 1948-1980 period.

Throughout the history of the harbor structures, littoral material has been impounded by the East Pier, while a small portion of the sediment has "bypassed" the harbor mouth to the shores to the west. The influx of sand due to bluff recession east of the study area probably began to increase as high lake levels caused shore protective works to fail and thus accelerated bluff recession. In summary, the postbreakwater period has experienced a littoral material movement into the accumulated fillet immediately east of the East Pier with resultant shoreline change fluctuations comparable to those that prevailed over the 1948-1973 period of prebreakwater construction.

(2) Beach Area Changes. The characteristic change in beach configuration that preceeded and followed the construction of the offshore breakwater in 1973 was accretion near the East Pier and accelerated erosion along the central portion of the study reach. Study of fluctuations of beach area along the east shore shows a total loss of only 0.06 acre from the system for the 1948-1973 period (see Table 5.7). The total change for each time period shown represents net gains or losses to the system. Material moves around the pier's ends, resulting in realignment of the various beaches within the system according to the predominant wave and storm direction during that time period. Over the total 1948-1980 period only 0.09 acre of beach were estimated lost from the system.

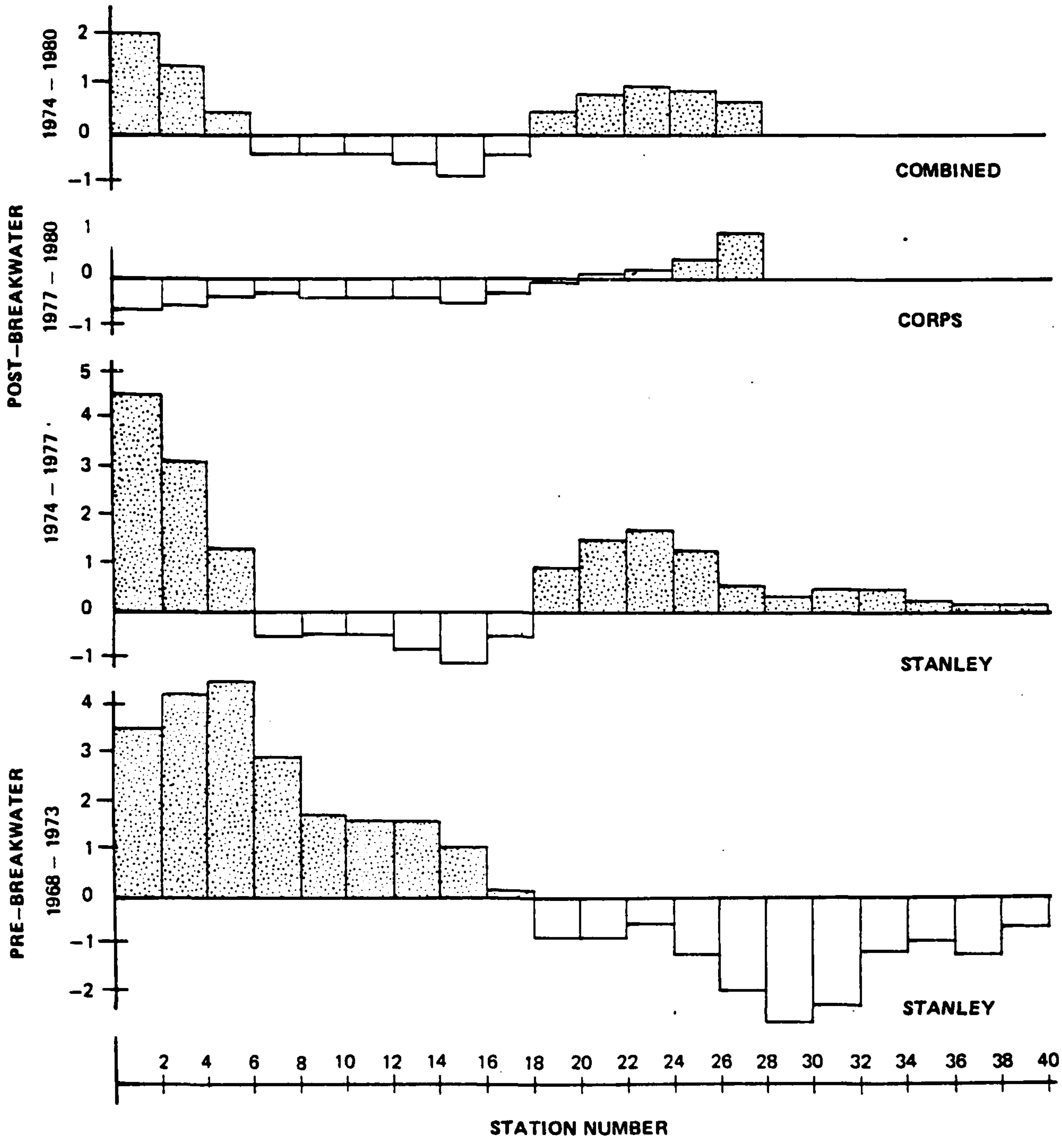
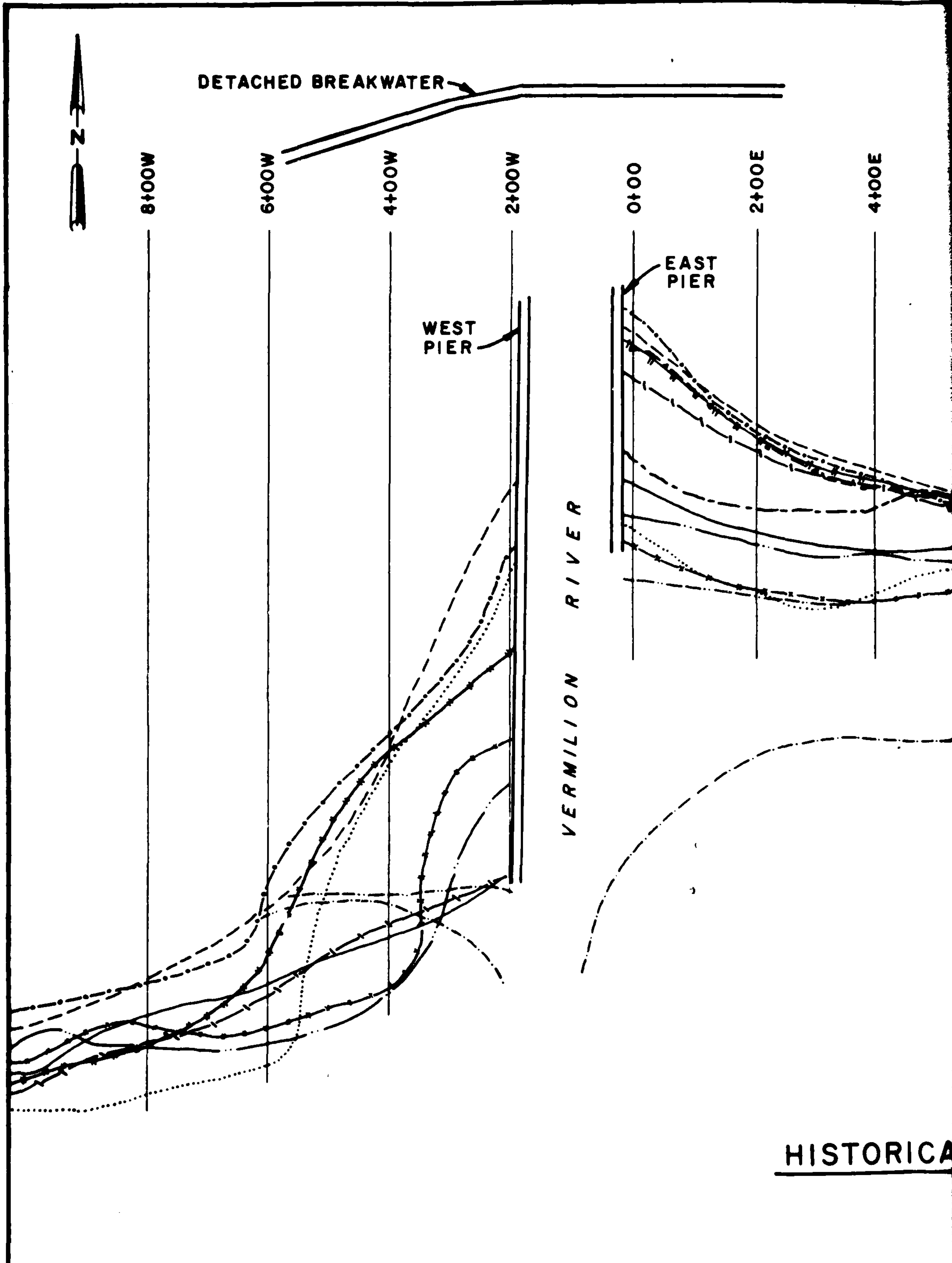
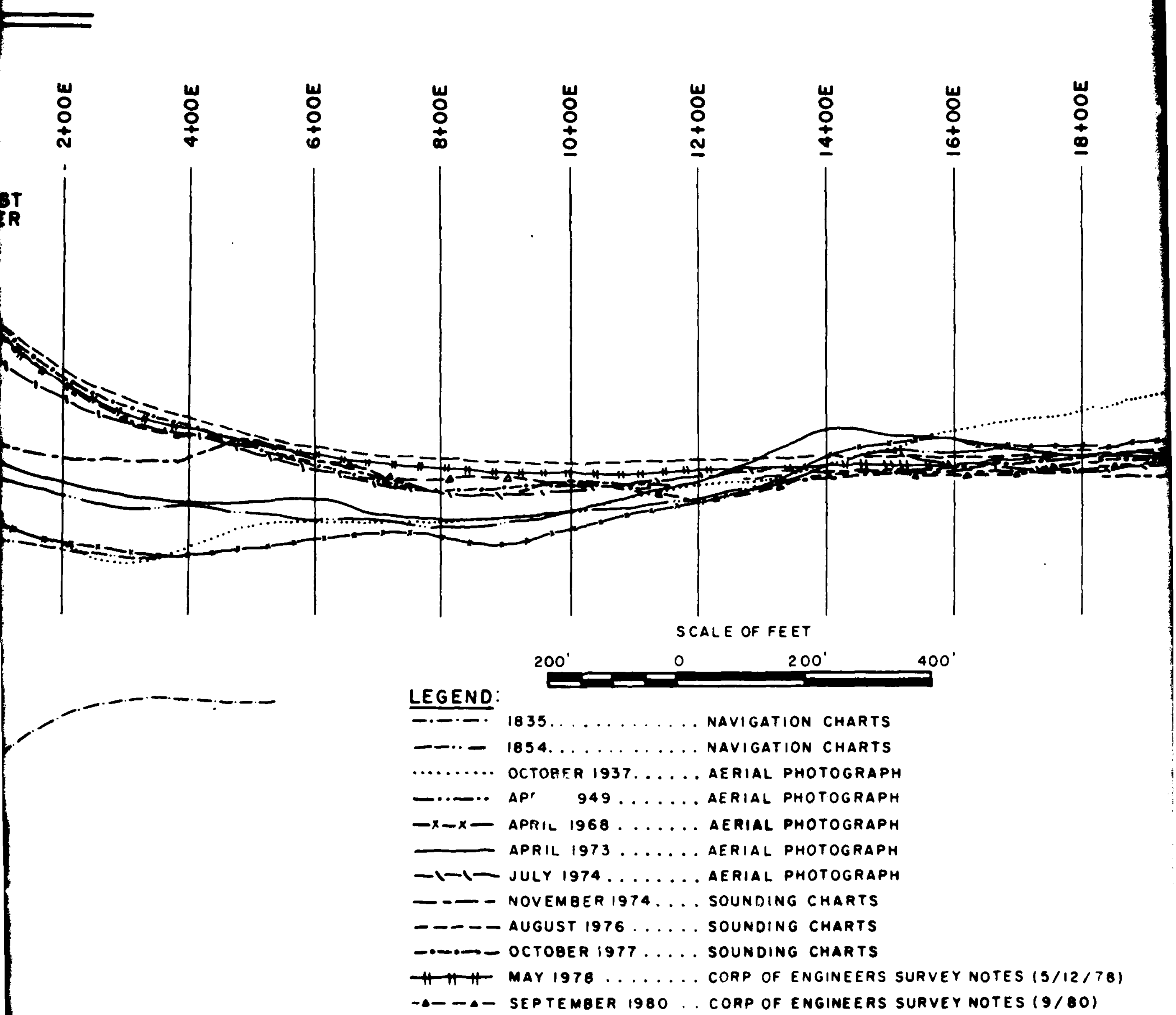


Figure 5.5 LONG TERM VOLUMETRIC CHANGE, VERMILION, OHIO (THOUSAND CUBIC YARDS PER YEAR)

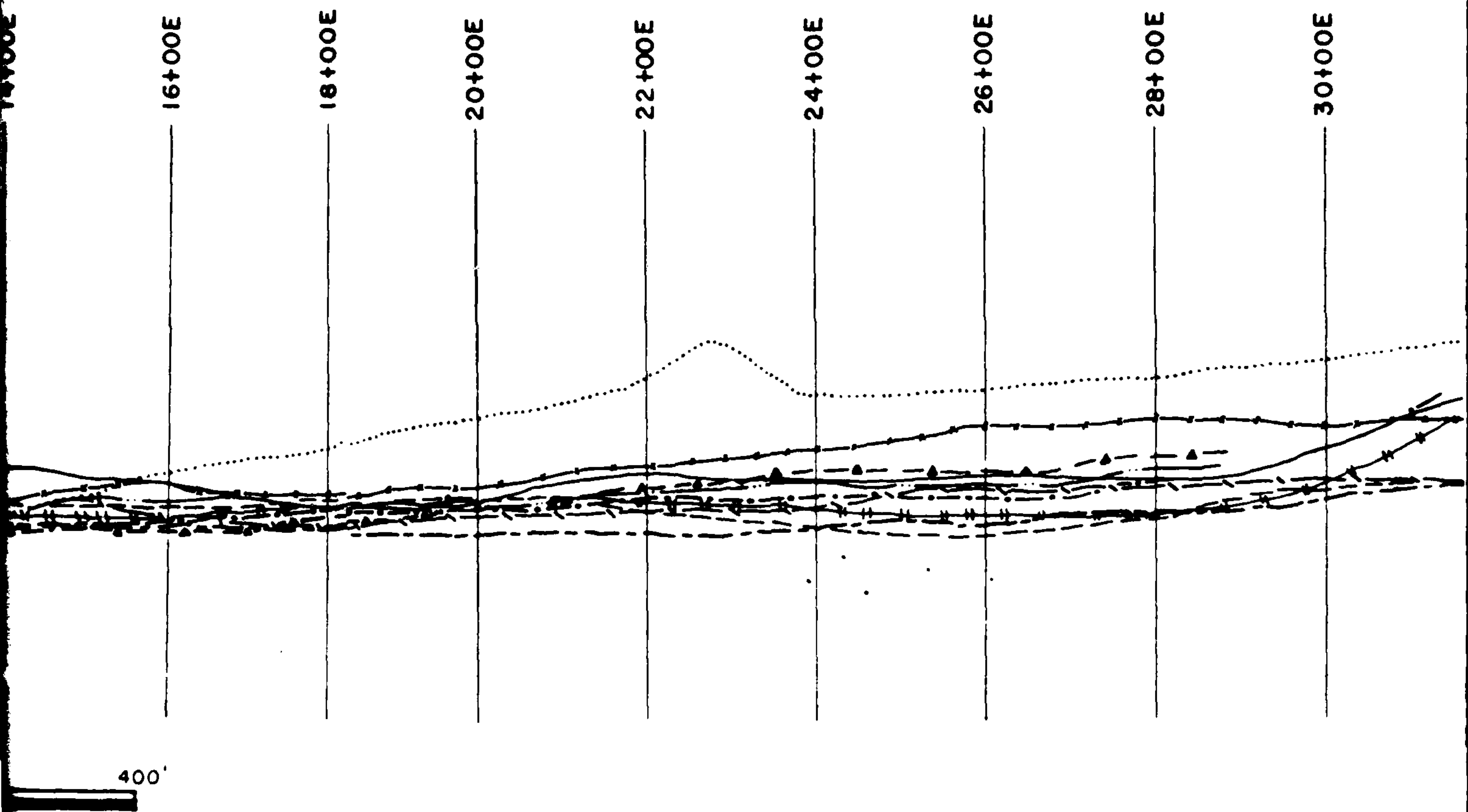

DETACHED BREAKWATER
N
8+00W
6+00W
4+00W
2+00W
0+00
2+00E
4+00E
EAST PIER
WEST PIER
VERMILION RIVER

HISTORICA



HISTORICAL POSITIONS OF LOW WATER DATUM CONTOUR

2



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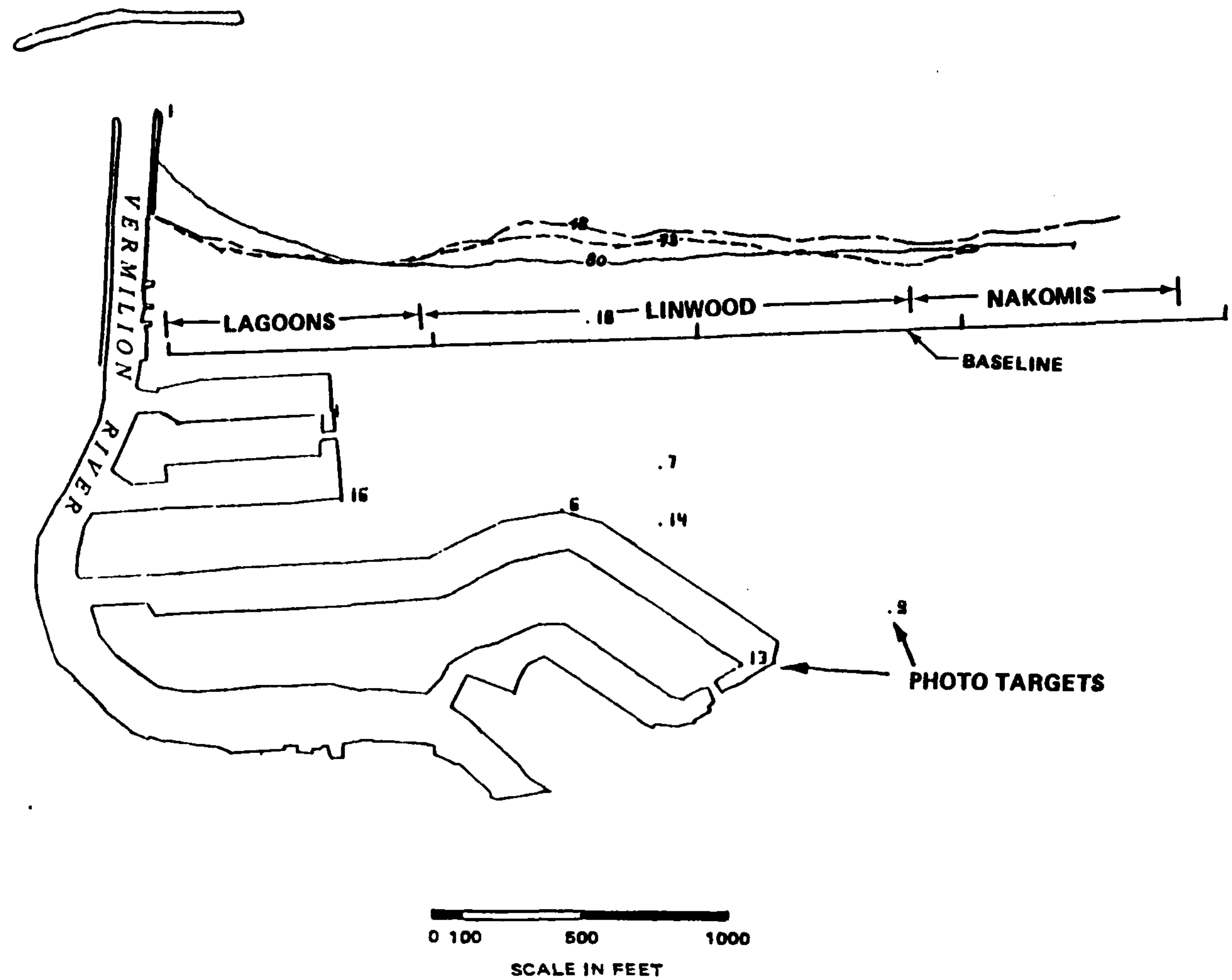
NOTES:

THE LINES SHOWN REPRESENT THE POSITION OF THE L.W.D. CONTOUR AT THE TIMES SHOWN.

L.W.D. = 568.6 FT. (I.G.L.D. 1955)

ATUM CONTOUR

FIGURE 5.6



SHORELINE LOCATIONS EAST OF VERMILION HARBOR, OHIO

FIGURE 5.7

East of the harbor, the western end of the pocket beach at Lagoons Beach was highly variable in width, as was its eastern end at Nakomis. Storms from the east would drive sand toward the Lagoons end and increase movement of sand around the ends of the piers. Storms from the west would drive sand from Lagoons toward Nakomis with some localized scour at the East Pier due to wave reflection off of the smooth stone pier face. Westerly sand movement dominated, thus the long-term balanced condition favored a wider beach at Lagoons and a narrower beach toward Nakomis. The length of shore protected by this east shore fillet varied as sand was driven more toward one end or the other, and as the actual volume of the sand in the fillet fluctuated in response to climatic variations. Lake levels, storm activity, and private shore protection works along the downdrift and updrift shores influence bluff recession rates and the offshore sand movement. Thus, they modify the quantity of sand entering and leaving the shores adjacent to the harbor.

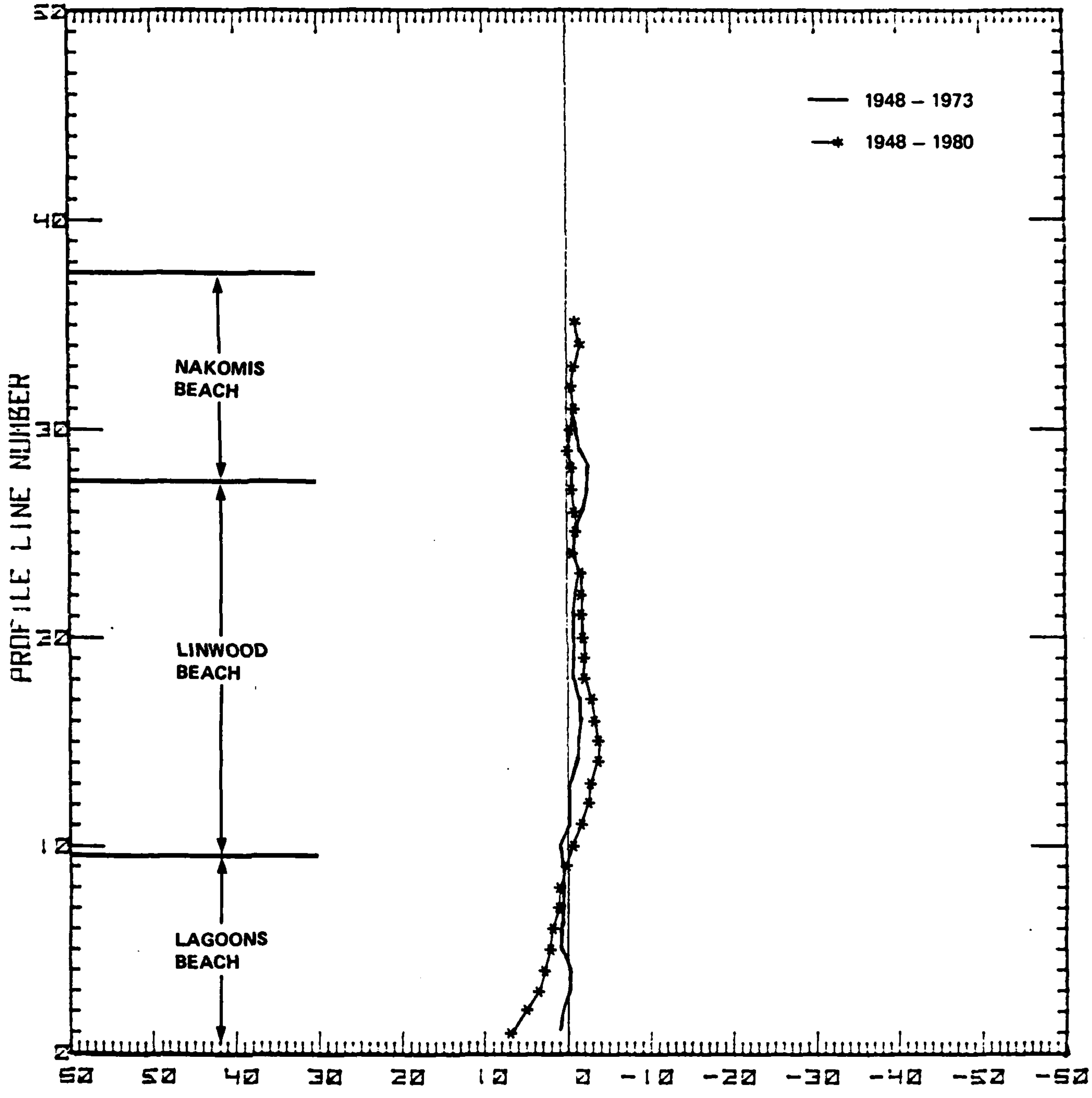
Because of dense vegetation or too much foliage which blanket the bluffline in new available aerial photos the bluff crest cannot be easily delineated and therefore no new bluff analysis is presented. Nevertheless, any bluff recession on this section of beach is caused by processes other than direct wave impact. Wave-induced erosion may be a contributing factor on the eastern portion of Nakomis Beach, but the shale bluffs of this area are highly resistant to erosion with rates less than 1 foot per year.

Table 5.7 - Beach Area Change (Acres)

Period	Lagoons Beach	Linwood Beach	Nakomis Beach	Total Change	
1948 - 1968	-0.94	+0.21	+0.81	+0.08	
1968 - 1973	+1.20	-0.92	-0.42	-0.14	
					-0.06
1973 - 1974	+1.84	-1.21	-0.05	+0.58	
1974 - 1978	+0.11	-0.42	+0.07	-0.24	
1978 - 1980	-0.34	-0.16	+0.13	-0.37	
		1948-1980 Change		-0.09	

SOURCE: Appendix A of this report: Tetra Tech 1981 report on east of Vermilion Harbor shore and bluff changes.

VERMILION SL STUDY #2



SHORELINE CHANGE RATE (FT./YR.)
USING CORRECTED SHORELINE

FIGURE 5.8

d. <u>Impacts of the Breakwater on Shoreline Trends to the East of the Harbor Structures</u> - One cannot rationally isolate the impacts of the breakwater on shore processes from those of lake level variations and storm activities at the Vermilion Harbor. As lake levels lower, the shoreline change rate slows and finally reverses. Redistribution of beach material occurs, creating either erosion or accretion. Prior to completion of the breakwater (1971-1973), high level accretion was taking place adjacent to the East Pier and all along Lagoons and the western portion of Linwood Beach. The eastern portion of Linwood Beach, and Nakomis Beach were experiencing erosion. The accretion was evidently the result of unusual high lake levels coupled with a predominant wave direction from the northeast. In the 1973-1974 period, which included breakwater completion, the level of accretion along Lagoons Beach had doubled to a maximum rate of 120 ft/yr as Linwood Beach suffered average erosion on the order of 40 ft/yr. In this timeframe, the effect of the high water and dominance of waves from the northeast has been westerly movement of nearshore sediment to the lee of the breakwater causing rapid beach growth adjacent to the east harbor pier and along Lagoons Beach.

In the 1974-1977 and 1977-1979 time periods, recovery began to take place on Linwood and Nakomis Beaches with the Lagoons Beach area fillet accreting slightly in 1974-1977 but eroding in 1977 to 1979. In the 1979-1980 time period, the entire stretch of Lagoons Beach is shown eroding, and the central and eastern Linwood and Nakomis Beaches accreting well. Apparently in the period 1977 to 1980 (especially 1979 to 1980) the predominant wave direction has shifted to the northwest helping to redistribute beach materials to the east. Redistribution of materials accumulated adjacent to the East Pier is affected by the presence of the breakwater in shielding this area from northwest waves. The trends from the 1977-1980 period (Figure 5.5) further suggest that shoreline fluctuations during this period are comparable to those that prevailed over the 1948-1973 period.

For the 1948-1980 period, the total surface area change in the Lagoons-Linwood-Nakomis Beach area equals -0.09 acre (Table 5.7), indicating little long-term net change in sand volume to the pocket beach as a result of high lake level and the breakwater construction. Most of the beach movement is a result of reorientation of various beaches within the system according to the predominant wave and storm direction during that time period.

The imbalance due to the sheltering of the Lagoons Beach has proved to be temporary, since the sheltered area has stabilized to existing conditions. Once "filled," westerly movement into the trap is reduced as the stable beach provides a base against which additional beach material can collect building a longer, broader, oscillating fillet. The salient behind the breakwater has become the stable west end of an oscillating Linwood-Nakomis Beach complex.

Within the 7 or 8 years since breakwater construction, the natural littoral influx from the east has apparently mitigated the immediate breakwater impacts. The temporary imbalance is quickly being corrected as high lake levels accelerate bluff recession, releasing greater than normal quantities of sand to the littoral system. The increased littoral load entering the Linwood-Nakomis Beach complex from the east is replacing the losses into the

breakwater salient. The sheltered Lagoons Beach has built out to an apparent maximum width. Since it has stayed remarkably stable over the past few years, and since various sampling programs have revealed only minor losses of littoral sands to the harbor entrance channel, the assumption is that the salient now appears to be filled and therefore balanced.

e. Summary of Conclusions Reached by Tetra Tech Regarding Effect of Breakwater on Easterly Shoreline - The shoreline east of the Vermilion Harbor has experienced significant changes over the 32-year study period during both pre and postbreakwater construction. Analyses of available data show a trend towards shoreline accretion along the beaches east of the harbor structures. Short-term trend comparison of the pre vs. postbreakwater periods indicated that the growth of the fillet adjacent to the East Pier during the years immediately before and just after breakwater construction had stopped and erosion was evident in the most recent series of photographic comparisons (see Photos 5.11 to 5.14). The eastern reaches of Linwood and the Nakomis Beaches were accreting in the 1977-1980 period indicating a possible west to east redistribution of beach material from the Lagoons segment during this period.

The beaches to the east will continue to experience fluctuations of the shoreline with negligible net erosion or accretion in the long-term. As summarized in the 1981 Tetra Tech Report (Appendix A of this report), ". . . the aerial photo coverage and the field survey data show that for the Lagoons-Linwood-Nakomis segments the trend of the shoreline before breakwater construction was that of slight accretion in the Lagoons, 1 to 2 feet per year recession for Linwood, and zero to 1-foot per year recession for the Nakomis segment. During and immediately after breakwater construction, there was substantial shoreline accretion in the Lagoons sector and increased recession in the Linwood and Nakomis segments. This postbreakwater trend of increased shoreline accretion for Lagoons and increased recession for Linwood and Nakomis progressively reduced and the data for the period 1977 to 1980 indicate the fluctuations and trend of the shoreline in the three segments are comparable to that shown for the prebreakwater period. This further indicates that the influence of the breakwater on the fluctuations and trends of the shoreline east of the East Pier have been minimal since 1977."

These conclusions reached by Tetra Tech regarding the effect of the breakwater on the easterly shoreline, clearly indicate the insignificance of that structure's influence on the shore processes at the Vermilion Harbor during the 1948-1980 study period.

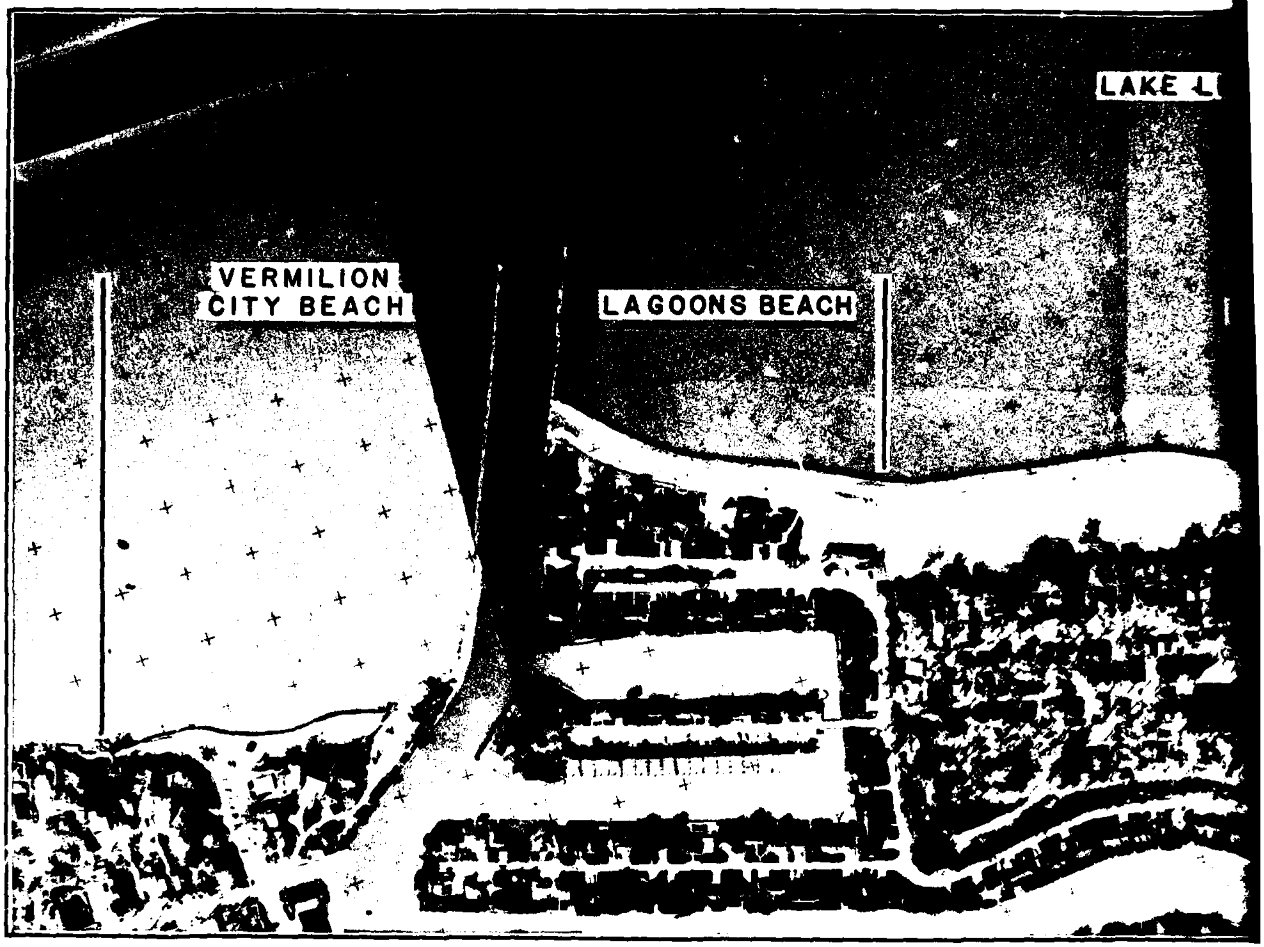


PHOTO 5.11

– BEFORE BREAKWATER CONSTR
LAGOONS, LINWOOD AND VERMILION CITY BEACHES UNDERWENT SEV
AERIAL PHOTO TAKEN 19 APRI

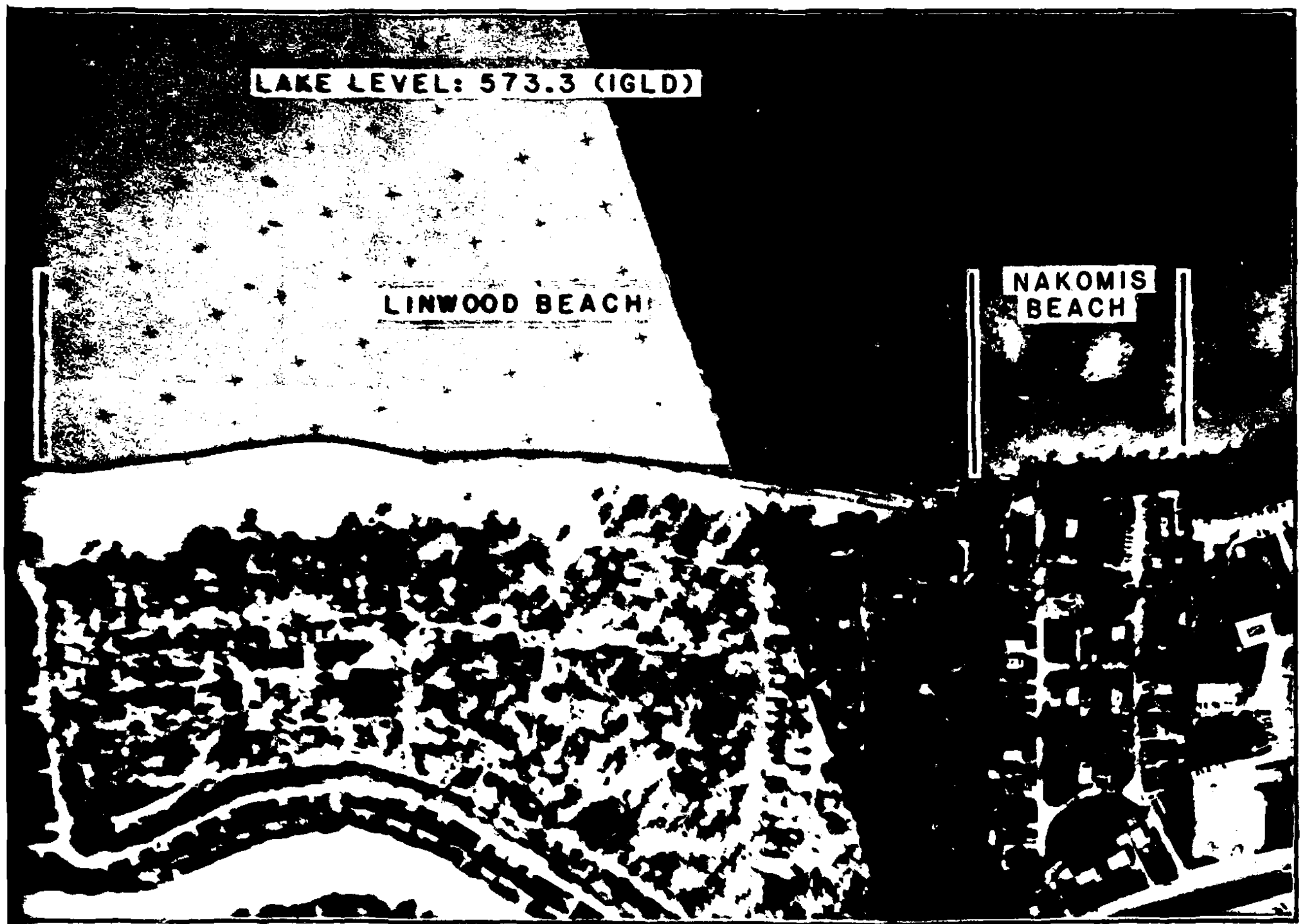


PHOTO 5.11

RE BREAKWATER CONSTRUCTION –
EACHES UNDERWENT SEVERE EROSION. NAKOMIS BEACH DID NOT EXIST.
L PHOTO TAKEN 19 APRIL 1973.

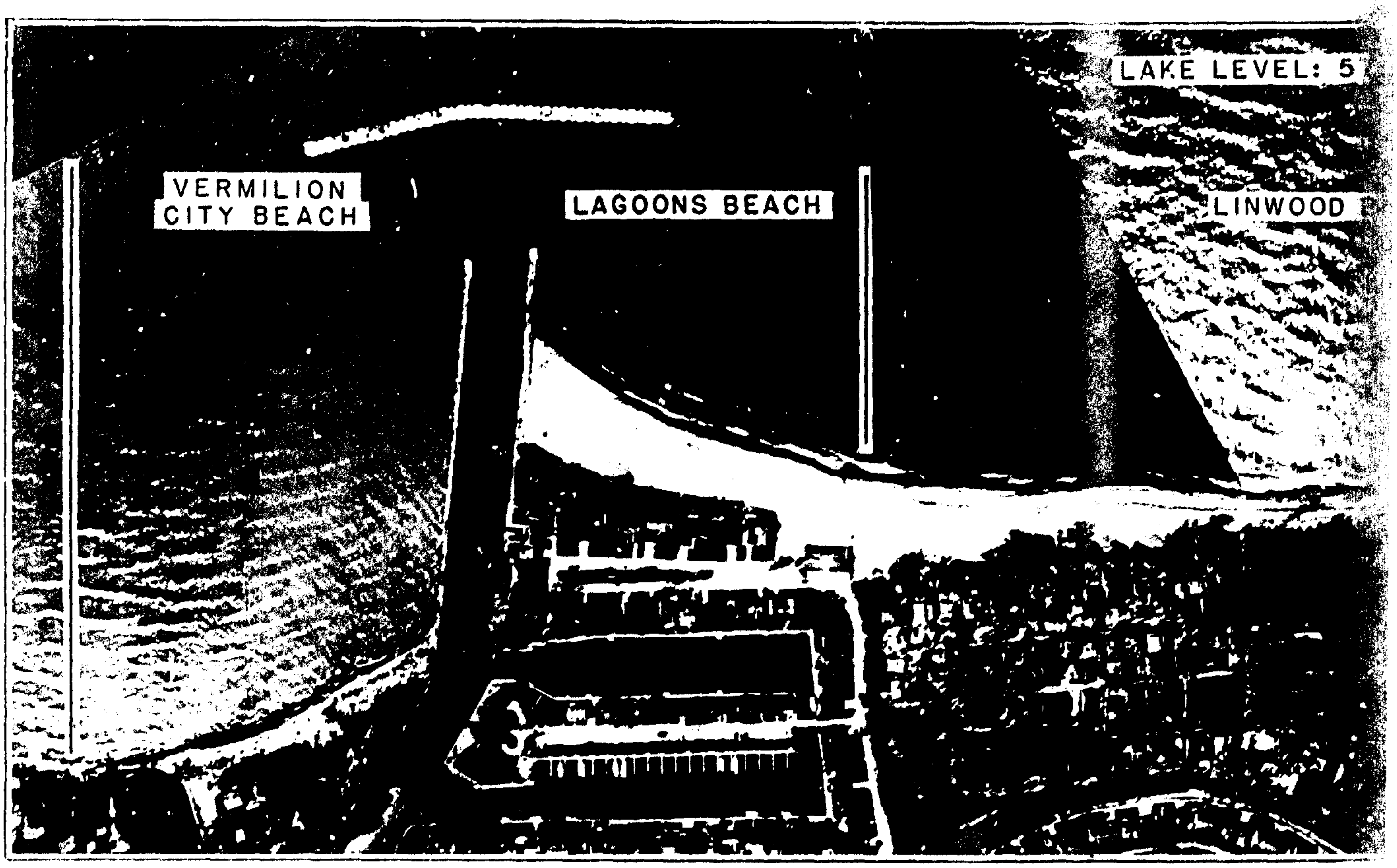


PHOTO 5.12

LAGOONS AND VERMILION CITY BEACHES ACCRETED AT THE EX
NAKOMIS BEACH WAS STILL NON-EXISTANT. AERIAL PHOT

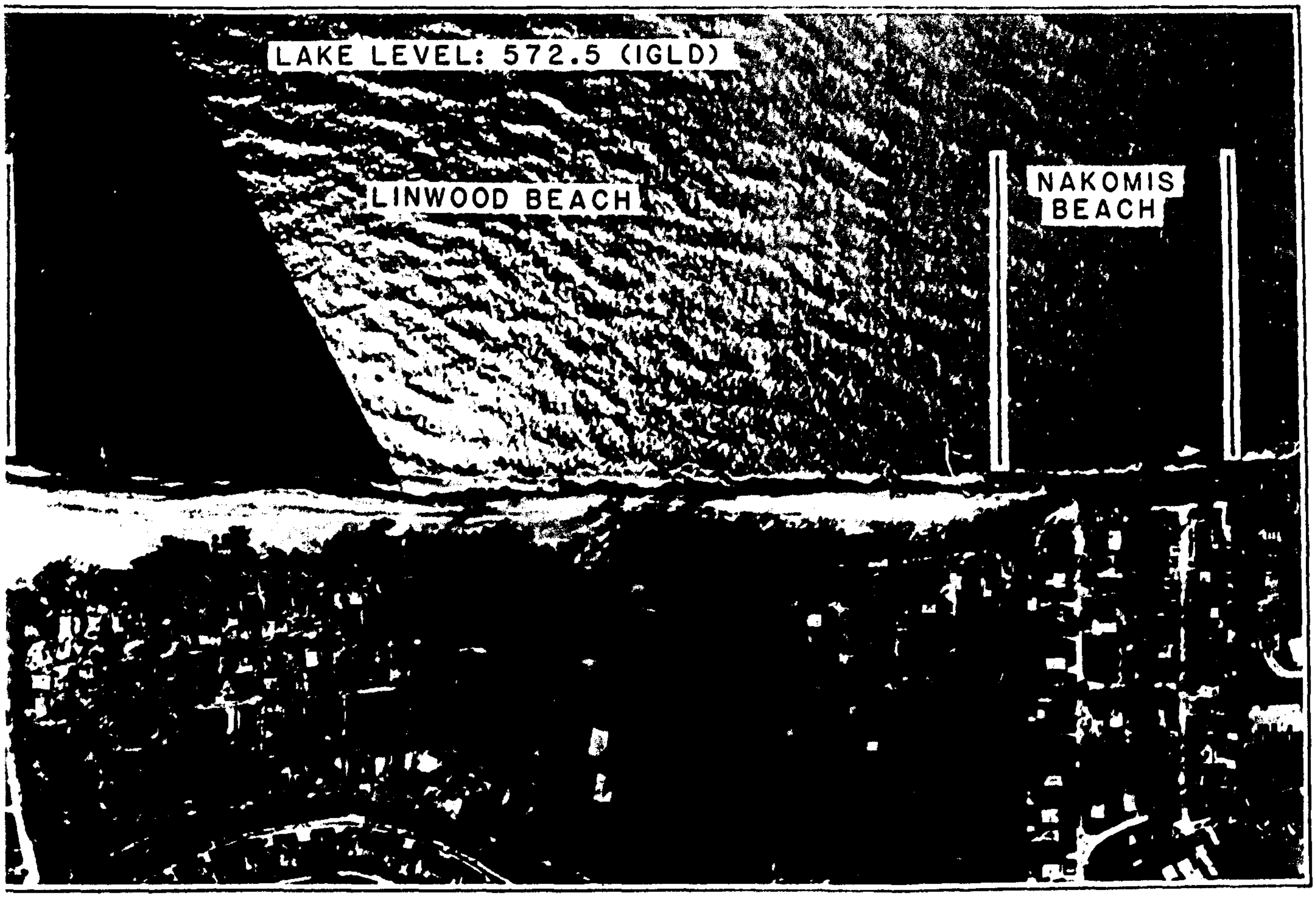


PHOTO 5.12

BEACHES ACCRETED AT THE EXPENSE OF LINWOOD BEACH.
NON-EXISTANT. AERIAL PHOTO TAKEN 23 APRIL 1980.

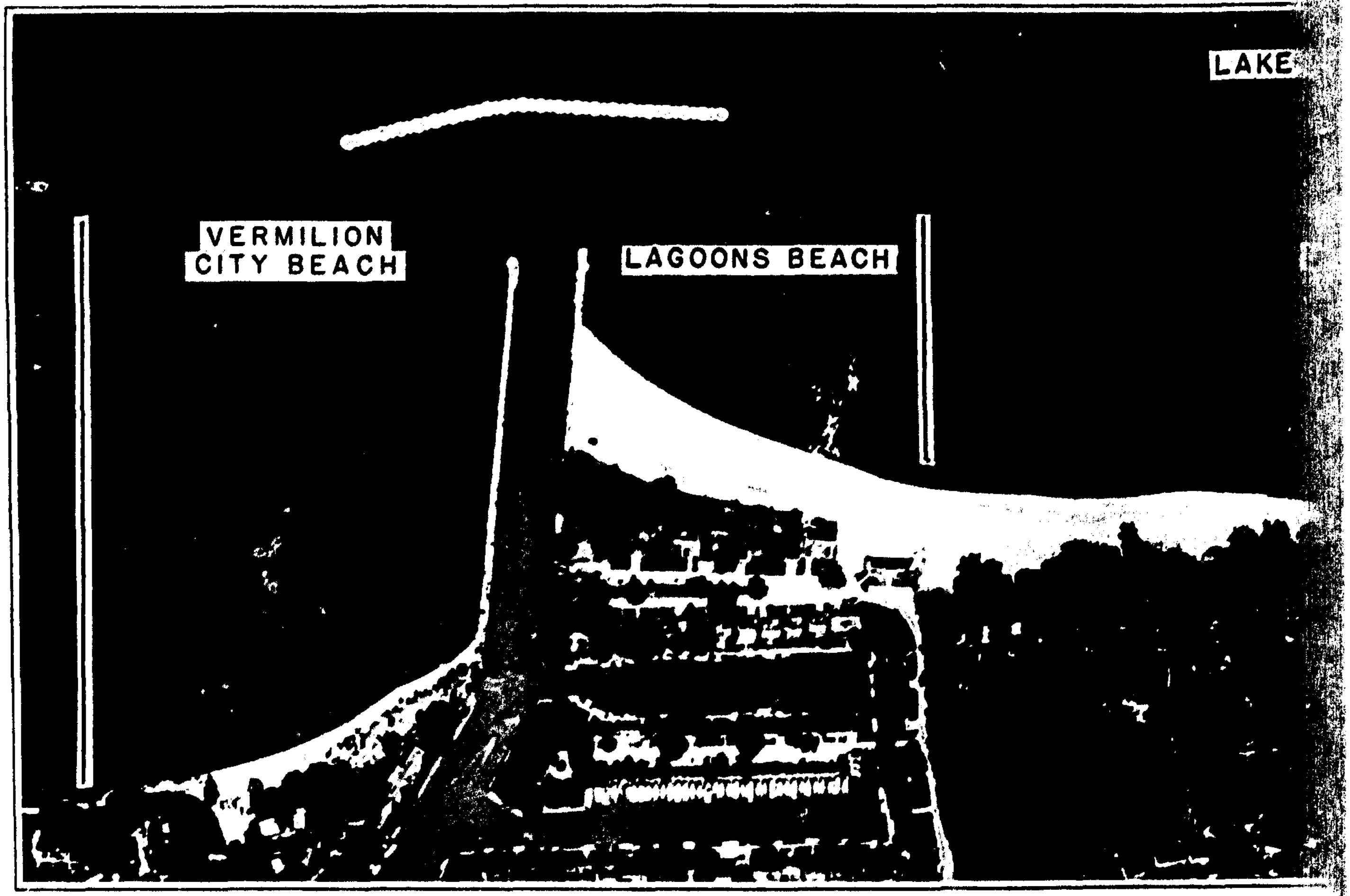


PHOTO 5.13

REORIENTATION PROCESS CONTINUED WITH SOME A
NAKOMIS BEACH REAPPEARED FOR THE FIR
AERIAL PHOTO TAKEN 8 SEPTE

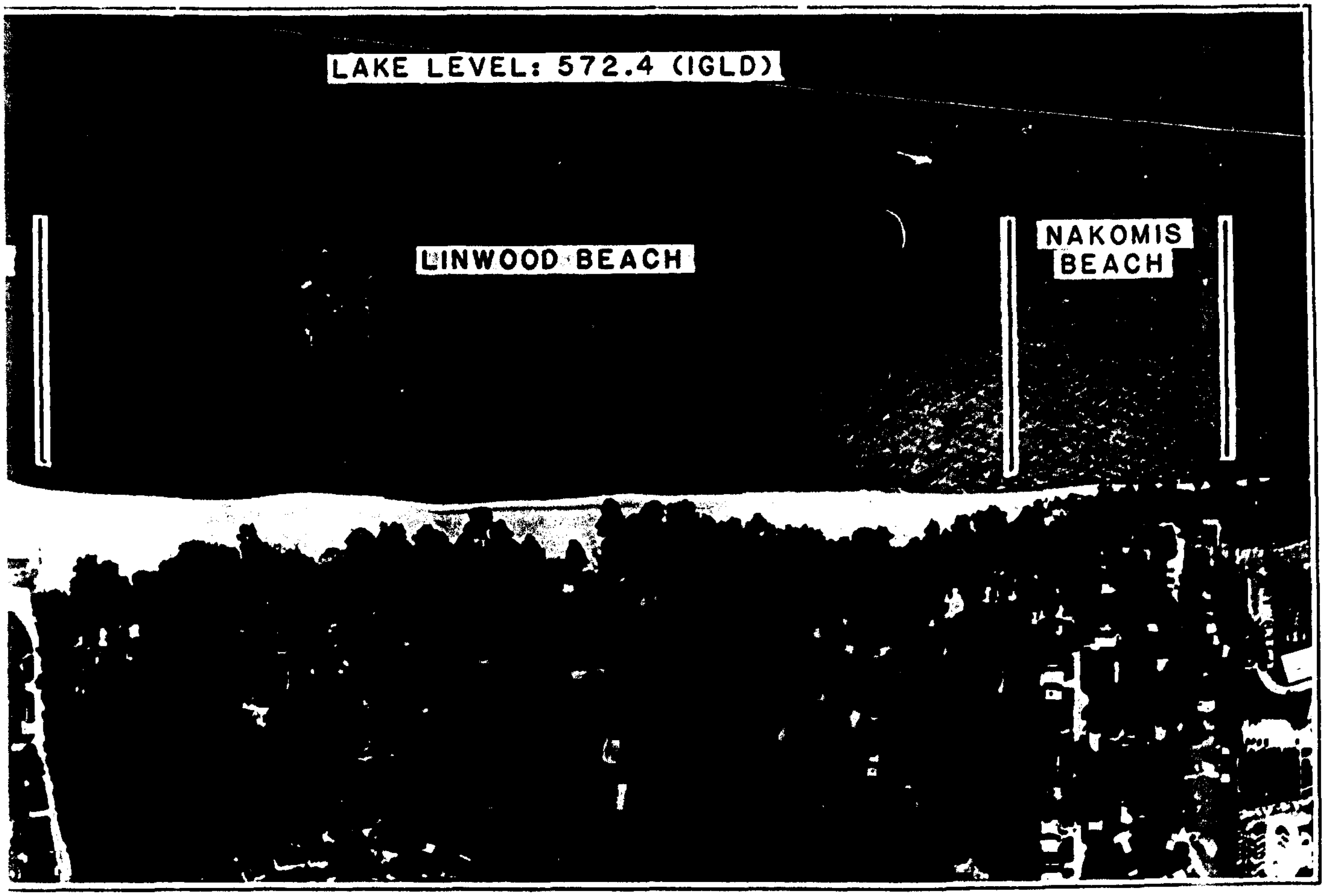


PHOTO 5.13

CONTINUED WITH SOME ACCRETION AT LINWOOD BEACH:
EAPPEARED FOR THE FIRST TIME SINCE 1973.
. PHOTO TAKEN 8 SEPTEMBER 1980.

2

PHOTO 5.1

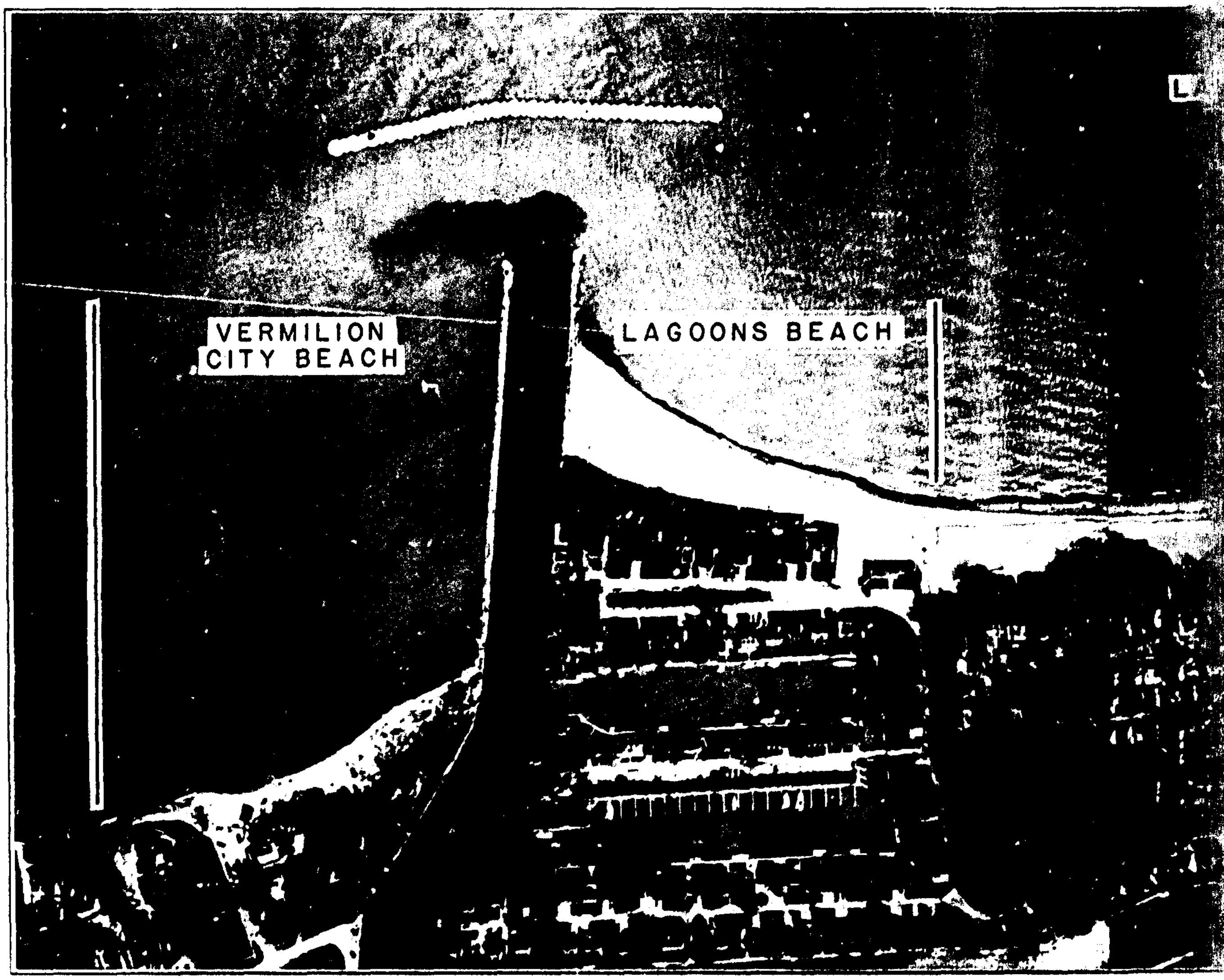


PHOTO 5.14

A STATE OF THE SHORELINE REORIENTATION PROCESS WHICH
FROM EROSION TO GROWING ACCRETION. AERIA

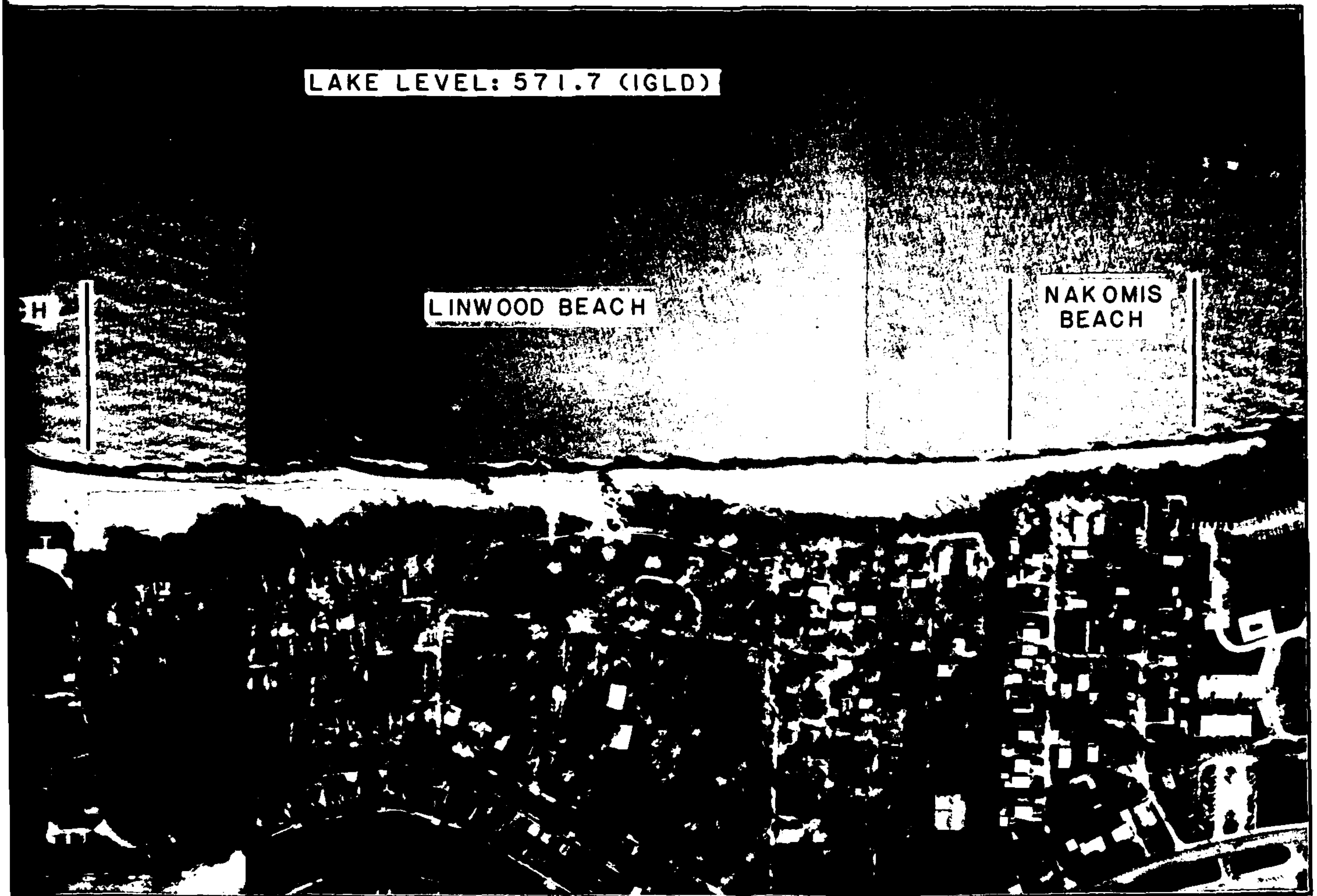


PHOTO 5.14
TION PROCESS WHICH CHARACTERIZES A REVERSAL OF THE TRENDS
ING ACCRETION. AERIAL PHOTO TAKEN 21 APRIL 1981.

2

PHOTO 5.14

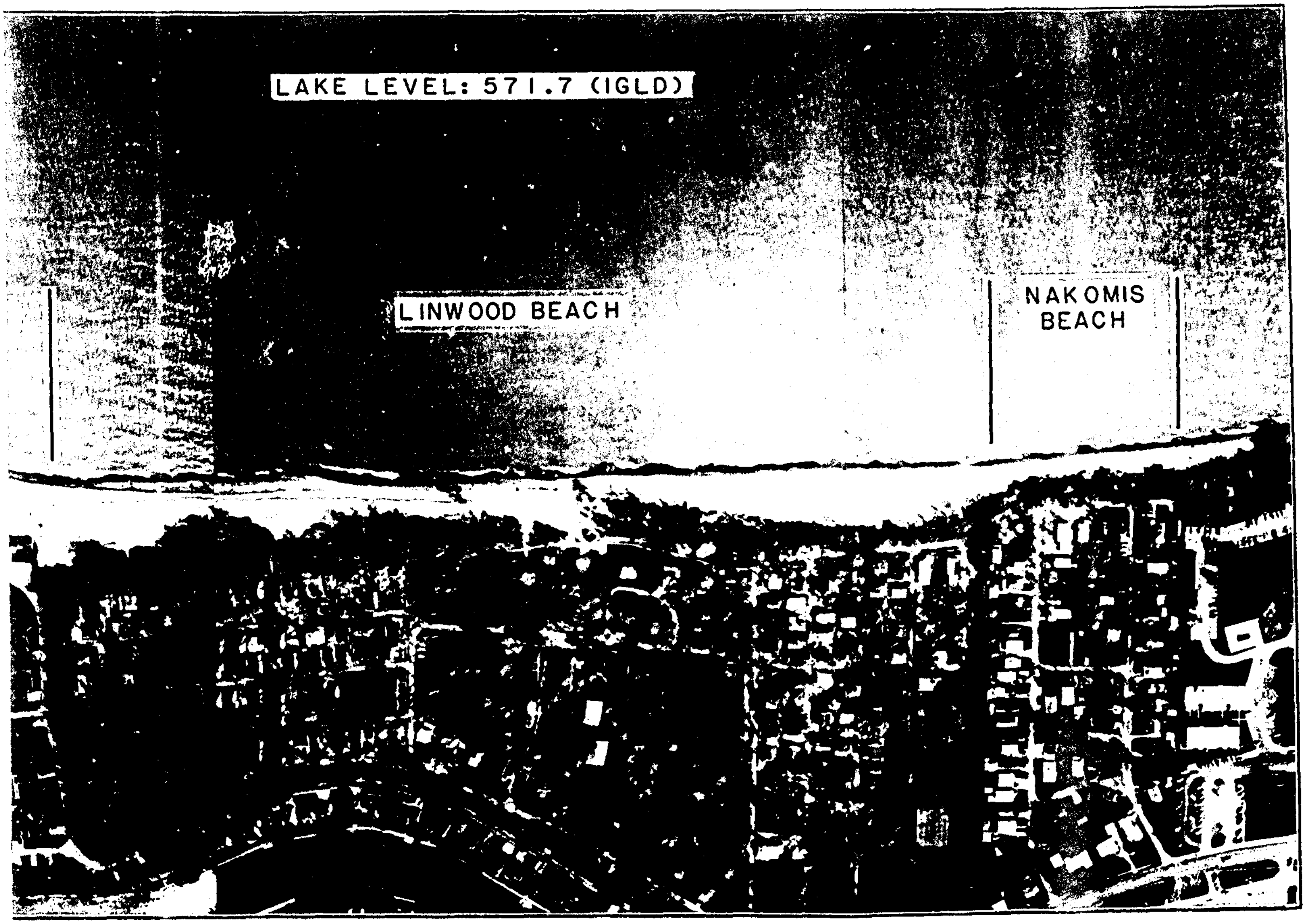


PHOTO 5.14

ON PROCESS WHICH CHARACTERIZES A REVERSAL OF THE TRENDS
IG ACCRETION. AERIAL PHOTO TAKEN 21 APRIL 1981.

PHOTO

SECTION VI
CONCLUSIONS

Overview

Since construction of the detached breakwater in 1973, several studies have been conducted to determine the effect that the Vermilion Harbor navigation structures have had on the contiguous shoreline. The purpose of these studies was to establish whether or not mitigation of any shoreline damages caused by the harbor structures is warranted under the feasibility criteria for Section 111 implementation. Those studies were conducted, for the most part, by private consulting firms under contract with the Buffalo District. Stanley Consultants conducted and completed the Stage 2 Study of the effect of the breakwater on the shoreline to the east of the harbor in May 1978. In order to refine the preliminary finding of the May 1978 report on shoreline conditions east of the harbor, further study was performed by Tetra Tech Inc., and completed in July 1981. Tetra Tech also completed in July 1980 a study of the shores to the west of the harbor to determine the extent of shoreline erosion and damages caused by the Federal navigation structures; and presented preliminary design and cost estimates for alternative mitigation plans.

a. Stanley Consultants May 1978 Report - The Stanley Consultants investigation was to determine the extent of shore damages, if any, attributable to the navigation structure, and recommend whether consideration of mitigation measures is warranted. Regarding the impacts of that structure on shoreline processes, they concluded that "the offshore breakwater constructed in 1973 has contributed significantly to shoreline reorientation at Vermilion; and that the reorientation is characterized by accretion near the piers and erosion at Linwood and Nakomis Beaches. However, the shoreline is approaching equilibrium and no further significant shifts due to the breakwater are anticipated." On that basis, they recommended that no further consideration of mitigation for beach erosion is required, assuming the beach is acceptable in its present state of equilibrium.

From this preliminary analysis by Stanley, the District concluded that mitigation of the loss of beach at Linwood should be undertaken and therefore recommended that further detailed investigation be undertaken.

b. Tetra Tech July 1981 Report - The Tetra Tech followup investigation was to reevaluate the need for mitigation of shoreline damages to the east of the harbor based on beach observation since 1978 which indicated that significant accretion was occurring at the eastern end of Linwood Beach and Nakomis Beach. Based on results of their investigation they commented that the shoreline east of Vermilion Harbor has experienced significant changes over the 32-year study period during both pre and postbreakwater construction; and that the beaches to the east will continue to experience fluctuations of the shoreline with negligible net erosion or accretion in the long-term. The postbreakwater trend progressively reduced and the data for the period 1977 to 1980 indicate that the fluctuations and trend of the shoreline in the three segments are comparable to that shown for the prebreakwater period. The District's recommendation(s) on shoreline mitigation action will be greatly influenced by the results of the final Tetra Tech 1981 investigation.

c. Tetra Tech 1980 Report - In the summer of 1979, Tetra Tech studied the shoreline to the west of the harbor structures to determine the amount of shoreline damages attributable to the navigation structure, prepare preliminary designs and cost estimates for a range of alternative mitigation plans, determine if mitigation of shoreline damages are economically justified and recommend the appropriate plan of action. Based on the analysis performed, Tetra Tech concluded that bluff erosion to the west of the harbor has been aggravated by the harbor piers and subsequent armoring of the adjacent shoreline (bluff recession rate = 1.4 feet/year producing total annual damages of $22,770). Approximately 29 percent of the erosion is attributable to the harbor structures, specifically the harbor piers constructed in 1837. They concluded that none of the structural alternatives are economically feasible. In reviewing the benefit categories, they noted that, because of beach construction, recreation was the predominant benefit category. They then recommended that "no-action" be taken under Section 111 to mitigate the ongoing erosion that has been induced by the harbor structures at Vermilion. The District concludes that the conclusions reached regarding shoreline erosion rates and shoreline damage to the west for both the pre and postharbor project conditions are reasonable. The benefit analysis has been revised to meet Corps standards (see Economic Reevaluation, Attachment 1 to Appendix B). Inclusion of these benefits however, has not changed the economic efficiency of the plans investigated to any significant degree.

Buffalo District's Conclusions

Based on results of the investigative studies presented in this report, regarding alleged shore damages attributed to the U.S. breakwater at the Vermilion Harbor, the Buffalo District concludes the following:

a. The post-breakwater trend of increased shoreline accretion indicates that the influence of the structure on fluctuations and trends of the shoreline east of the East Pier have been minimal since 1977. It reflects an overall decrease in recession rate mainly caused by shore-protective structures built along the Vermilion reach on the south shore of Lake Erie.

b. The presence of the breakwater has simply contributed to a process which has long existed before the 1973 harbor improvement works. Its effects are minimal in comparison to all of the other factors involved.

c. No long-term loss of recreational usage on both public and private beaches is anticipated. Therefore, any past or future loss of recreational usage is only temporary in nature, and disappears as the process reverses itself.

d. The long-term trend in the unfortified bluffs of the study reach is clearly one of erosion; but the quantification of these losses must be based on consideration of erosion rates of less than 1 foot per year. Therefore, no major erosion-induced property loss is foreseen.

e. Area aesthetics, community well-being, and local residents' "peace of mind" are not threatened by any persistent continuing shore erosion attributable to the navigation structure.

f. The interceptor sewer outfall at Linwood Beach is and will be protected by the continued growth of the beaches to the east which act as an adequate buffer zone preventing any wave-induced bluff recession. These beaches have not been found subject to any permanent state of erosion because of the U.S. breakwater.

g. The breakwater did undoubtedly impose some immediate adverse impacts on the study area, but it is beyond the state-of-the-art or details of the existing data record to isolate these impacts of the breakwater from those caused by the extraordinary lake conditions of the early 1970's.

h. The initial breakwater impacts associated with high lake levels were temporary and are naturally abating toward future conditions which are foreseen with no significant adverse impacts. The Lagoons Beach is stabilizing as a wider than the pre-1973 beach. The Linwood-Nakomis Beaches will continue to fluctuate as they did prior to 1973 with some evidence that they will eventually adjust to a slightly larger volume beach because of the increased trapping of the east-to-west littoral load.

i. The history of shore recession in the Vermilion area bears witness of past and present accretion and erosional trends which suggest no alarming future conditions. It does clearly indicate a continuing process, one which is recurrent, cyclic in nature, and as normal as day and night.

SECTION VII

RECOMMENDATIONS

Recommendation

As a result of the study findings and conclusions, I recommend that no mitigative plan be implemented for the shores updrift (east) and downdrift (west) of the Vermilion Harbor entrance structures under the authority of Section 111 of the River and Harbor Act of 1968 (PL 90-483).

Robert R. Hardiman
ROBERT R. HARDIMAN
Colonel, Corps of Engineers
District Engineer

SECTION VIII

TERMINATION OF THE DPR

Termination Action

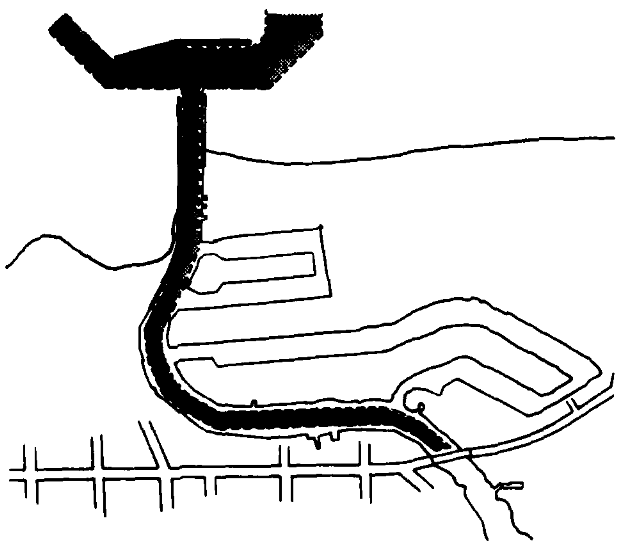
The North Central Division approved this Detailed Project Report and so notified by letter dated 15 October 1982, the Office, Chief of Engineers of the decision to terminate the studies.

VERMILION HARBOR, OHIO

DETAILED PROJECT REPORT ON SECTION 111

SHORE EROSION STUDY

STAGE 3 DOCUMENTATION



APPENDICES

U.S. ARMY CORPS OF ENGINEERS
BUFFALO DISTRICT
1776 NIAGARA STREET
BUFFALO, NEW YORK 14207

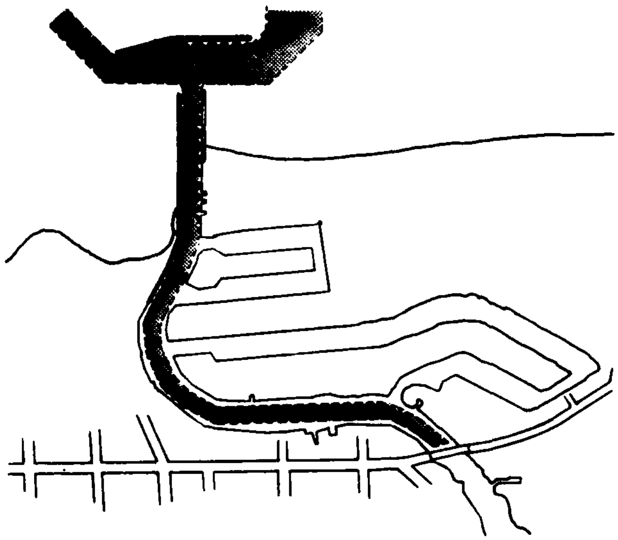
September 1982

VERMILION HARBOR, OHIO

DETAILED PROJECT REPORT ON SECTION 111

SHORE EROSION STUDY

STAGE 3 DOCUMENTATION



APPENDIX A

SUMMARY EVALUATION OF HISTORICAL SHORE AND BLUFF EAST OF HARBOR

U.S. ARMY CORPS OF ENGINEERS
BUFFALO DISTRICT
1776 NIAGARA STREET
BUFFALO, NEW YORK 14207

September 1982

TC 3391-02
JULY 1981

FINAL REPORT

SUMMARY EVALUATION
HISTORICAL SHORE AND BLUFF CHANGES
EAST OF VERMILION HARBOR, OHIO

PREPARED FOR
UNITED STATES ARMY
CORPS OF ENGINEERS
BUFFALO DISTRICT

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1.0 THE STUDY

1.1 INTRODUCTION

The Federal Government initially authorized the construction of harbor improvements at Vermilion, Ohio, in 1836. The purpose of the first harbor structures was to transform the harbor from a shallow, limited-use facility to a major port on Lake Erie devoted to the promotion of regional commerce and trade.

With limited development as a primary lake port, the main focus of the harbor users became the pursuit of recreational boating and commercial fishing. The most recent harbor improvement was completed in 1973 and consists of an 864-foot long detached breakwater located 300 feet north of the harbor entrance piers. In addition, the entrance channels to the harbor were widened and deepened at that time.

Following the completion of the breakwater construction, local citizens expressed the belief that the detached breakwater altered the shoreline east of the east pier significantly and through the Ohio Department of Natural Resources, requested the Corps of Engineers, Buffalo District, to investigate the problem under the authority of Section 111 of Public Law 90-483. The Buffalo District completed a Reconnaissance Study Report (stage 1 of the three stage Section 111 investigation procedure) in January, 1976. The findings and recommendations of the Reconnaissance Study Report indicated that a detailed study should be made (Stage 2 of the Section 111 procedure) to quantify any damages and investigate alternatives that would solve the problem. This was performed and presented in the Stage 2 Detailed Project Report (DPR), completed in May, 1978.

The Stage 2 study concluded that, although the breakwater had contributed significantly to shoreline reorientation east of the Vermilion Harbor Piers, the shoreline appeared to be approaching

equilibrium and no further shifts due to the breakwater were anticipated.

In September 1980 further study was undertaken to identify present as well as historical changes in the shoreline east of Vermilion Harbor. Aerial photographic analysis revealed that in the period 1977 to 1979 some measure of recovery was underway at previously eroding Linwood Beach with promise of recovery at Nakomis Beach.

1.2 PURPOSE

Using computer supported aerial photo analysis techniques, this study seeks to document historical shore and bluffline changes east of the Vermilion Harbor piers. The photographic analysis will augment the previous analysis presented in the September 1980 report providing more comprehensive coverage during the periods pre and post-breakwater construction in 1973 and 1974. In addition, 1980 aerial photographs will be evaluated to update trends reported in the earlier study for the post-breakwater recovery period.

Survey volume trends reported in the May 1978 Stage 2 report and from recent surveys by the Corps of Engineers in June 1979 and August 1980 will be compared with trends identified by aerial photo analysis. These comparisons will facilitate the documentation of historical changes of the Lagoons, Linwood and Nakomis Beach system and provide a basis for determining the impacts of the breakwater on shoreline configuration.

1.3 LOCATION AND DESCRIPTION

Vermilion Harbor, located at the mouth of the Vermilion River in Erie County, Ohio, is about 37 miles (by water) west of Cleveland, Ohio, as shown in Figure 1.3.1. Vermilion Harbor is comprised of east and west approach channels, the lower 3,600 feet of the Vermilion River, and four artificial lagoons. A detached breakwater built in 1973 by the Federal government shelters the approach

channels during moderately fresh wind and wave conditions and reduces wave and surge action in the harbor. The lagoons, constructed on the east side of the river by private interests, have depths averaging about 4 feet below the Lake Erie Low Water Datum elevation of 568.6 feet on the International Great Lakes Datum of 1955.

Until the Federal government constructed two jetties at the mouth of the Vermilion River in 1836, less than two feet of water existed over the bar at the Vermilion River mouth. The original jetties extended from each side of the river mouth lakeward to a depth of 10 feet. The distance between these parallel piers is 125 feet. The piers were composed of stone-filled timber cribs, each about 16 feet wide and 30 feet long with the top height of the cribs about five feet above Low Water Datum.

The Rivers and Harbors Act of 1875 authorized an increase in the Vermilion Harbor channel depth to 12 feet, extending from the 12-foot lake contour upstream for a distance of about 1,335 feet from the outer end of the entrance piers. The extensions increased the length of the east jetty to 1,075 feet and that of the west jetty to 1,125 feet. The pier construction and channel deepening was completed in 1878 except for a small rock area near the inner limits of the entrance channel.

The position of the lakeward ends of the jetties has not changed since 1878 except for minor alterations during pierhead reconstruction. The Federal government has made frequent and extensive repairs to both piers. Between 1907 and 1914, the entire timber superstructure was rehabilitated with heavy stone. In 1964, the elevation of the piers was raised from 6.2 to 6.5' above L.W.D.

To provide safer entrance conditions at Vermilion and to improve an access channel to the expanding harbor facilities further upstream, the Rivers and Harbors Act of 1958 authorized construction of overlapping "arrowhead" breakwaters at a distance of about

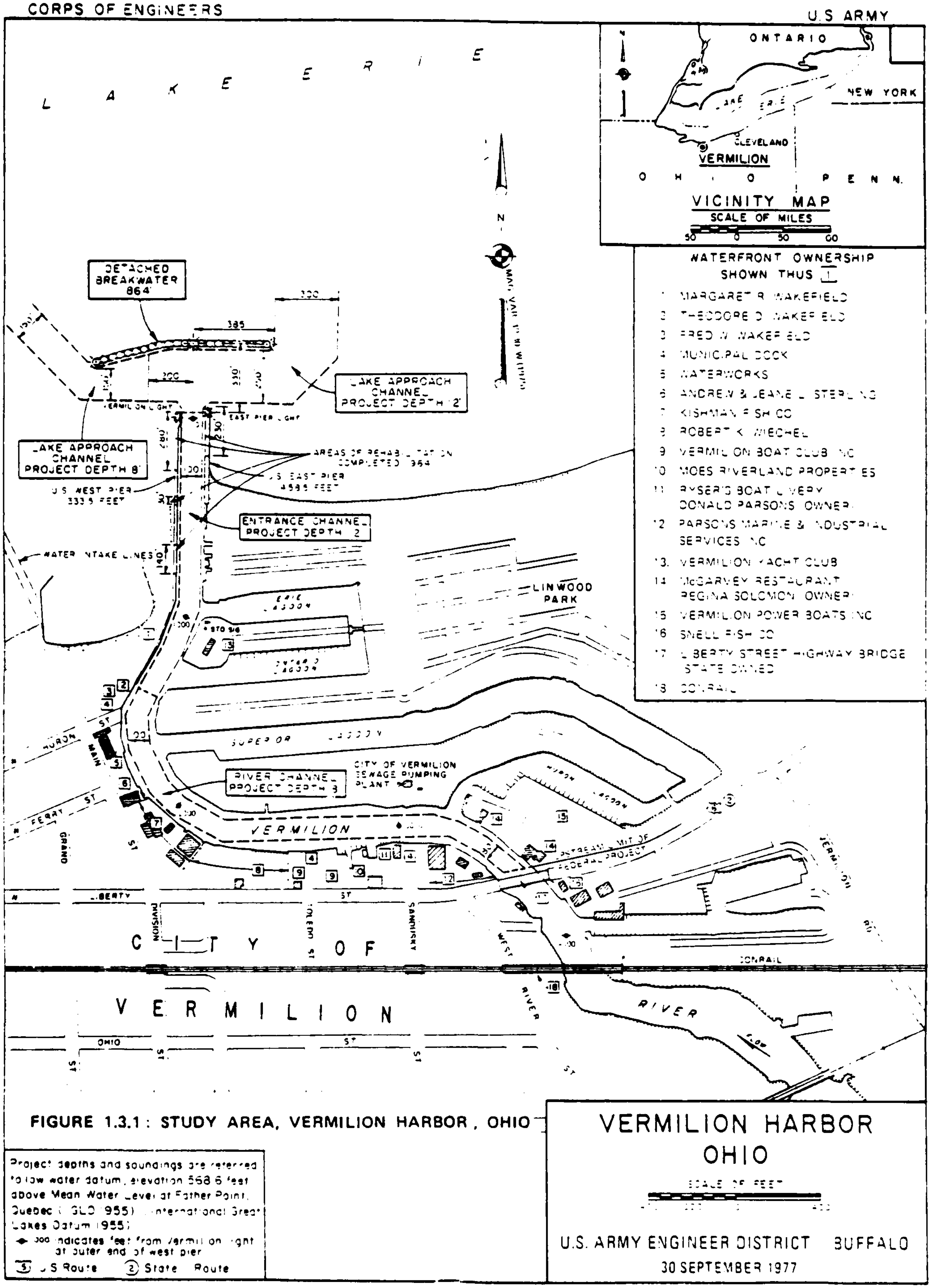


FIGURE 1.3.1: STUDY AREA, VERMILION HARBOR, OHIO

500 feet lakeward of the outer end of the east pier. The Act also authorized the extension of the 8-foot river channel further upstream. A model study of the proposed breakwater system was completed in 1969. The study, limited to investigating the effects of various structures on wave action, showed that the arrowhead breakwater plan did not provide sufficient wave protection for use of the harbor during all ice-free seasons. A single breakwater, located parallel to shore and about 300 feet lakeward of the outer end of the east pier, was selected as a more effective and economical alternative. In 1973, the Federal government constructed the breakwater, a "T" type cellular structure, and extended the federally-maintained river channel to a point 3,600 feet upstream from the east entrance pier.

1.4 PRIOR STUDIES

In the early 1950's the entire Lake Erie shoreline of Ohio was evaluated to determine significant erosion problem areas. This study, presented as House Documents 32 and 229 of the 83rd Congress (1952-1953), presented a qualitative description of shoreline erosion in the Vermilion area.

In 1964, a report entitled "Effects of Large Structures on the Ohio Shore of Lake Erie" was prepared by the Ohio Department of Natural Resources. This report briefly details the success of the parallel jetties in trapping a sandy beach east of the harbor for a distance of approximately 3,000 feet.

A model study in 1969 of the proposed arrowhead breakwater system led to the selection of a "T" type cellular breakwater parallel to shore due to wave considerations at the harbor entrance.

Due primarily to a public outcry concerning shore erosion to the east of Vermilion Harbor, a Reconnaissance Level Study under the authority of Section 111 of Public Law 90-483 was completed by the Corps' Buffalo District in January, 1976. Stage 2 of the three stage Section 111 procedure was initiated as a result of this

reconnaissance level report. Stanley Consultants prepared this Stage 2 report "Study of the Impact of the Federal Navigation Structures on Shoreline Processes" in May 1978 dealing principally with the shoreline to the east of Vermilion Harbor.

In July 1980 a further Stage 2 study on shores to the west of Vermilion Harbor, Ohio was completed by Tetra Tech, Inc. "The Impact of Federal Navigation Structures on Shoreline Processes, Vermilion Harbor, Ohio" determined the extent of shoreline erosion and damages to the west of the piers caused by the Federal navigation works and presented preliminary designs and cost estimates for mitigation alternatives.

In order to augment the preliminary finding of the May 1978 report on shoreline conditions east of Vermilion Harbor, a study was completed by Tetra Tech, Inc in September 1980 using sophisticated aerial photographic analysis of 6 photograph sets covering the period 1950 through 1979. Trends indicated in that study provided the basis for continued analysis to be performed under this study.

2.0 EXISTING CONDITIONS

2.1 LAKE ERIE WATER LEVELS

An integral part of any analysis of shoreline changes on Lake Erie requires prior knowledge on the variability of lake level during the study period. Figure 2.1.1 shows the monthly average lake level variation from 1950 through June of 1980; the period of study in this report. The date of each aerial photograph (except March 1948) used in this and the previous analysis is shown on the hydrograph. Also shown is the date of bathymetric surveys conducted by the Corps of Engineers which will be used to contrast volumetric trends of shoreline change to shoreline recession trends revealed by the aerial photographs.

The lake level that exists between two photographs or surveys plays a large part in the beach changes that occur in the intervening period. High lake levels cause wave impact to strike at higher beach elevations and thus induce major erosion. Low lake levels will cause wave energy to dissipate at more lakeward positions and cause corresponding lower levels of erosion or redistribution of beach material causing localized accretion. It will be useful to refer to Figure 2.1.1 when the results of the photo and volumetric analyses are presented in order to understand the extent to which the lake level contributes to beach reorientation. See Section 3.3 for a discussion of lake level adjustments needed to compare various surveys and aerial photographs from a common reference datum.

2.2 BATHYMETRIC CHANGES

Volumetric change data was supplied as government furnished information to be used in this study in contrast to the findings of aerial photographic survey data. The volumetric data is obtained by comparing successive bathymetric surveys at specific profiles along the shoreline in question to determine the erosion (or accretion) in cubic yards per year from a point on the berm

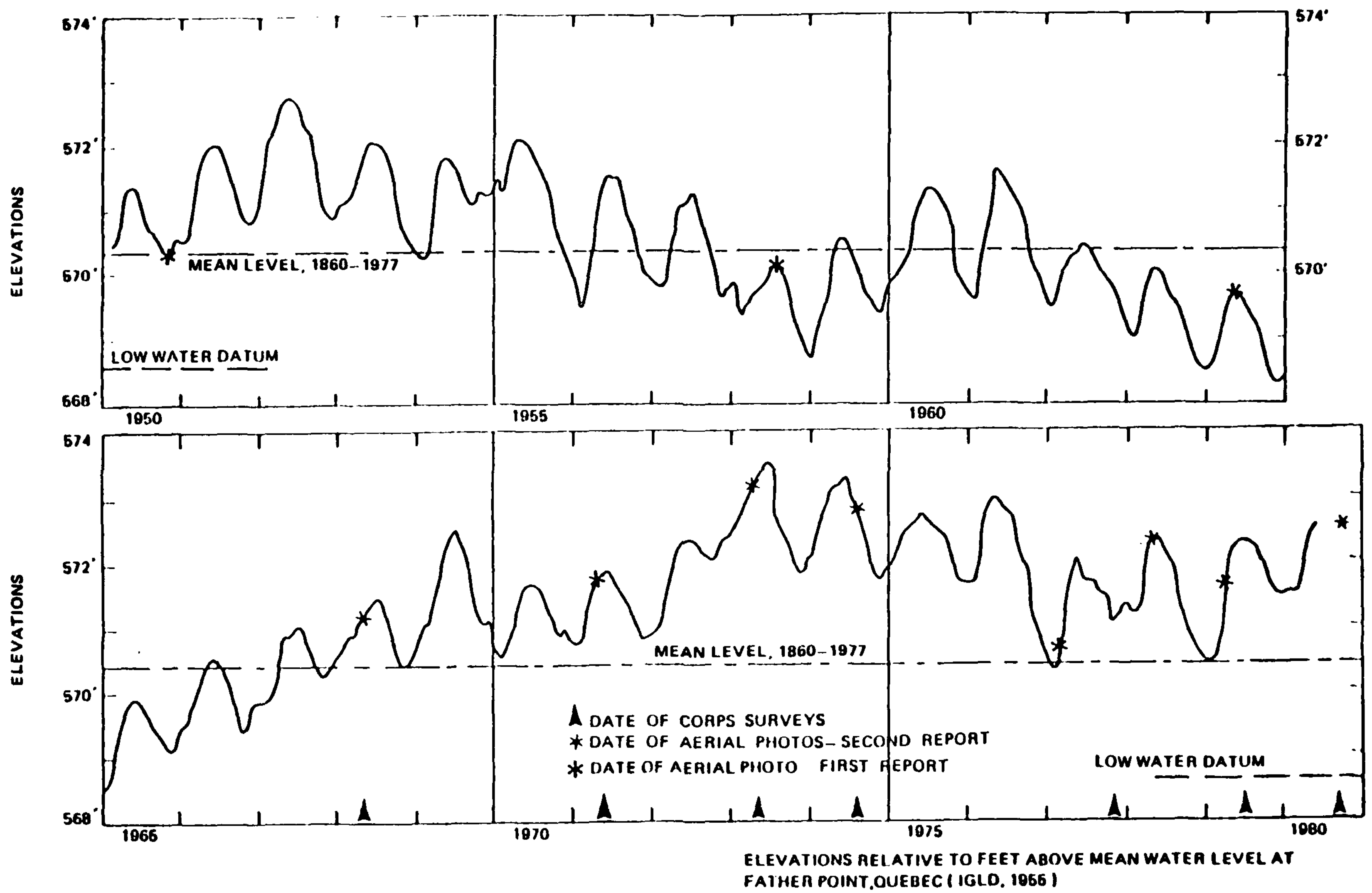


Figure 2.1.1 HYDROGRAPH OF MONTHLY MEAN LEVEL OF LAKE ERIE
1950 – 1980

above the low water datum to an arbitrary depth below LWD assumed to be the seaward limit of transport (point at which two successive profiles coincide).

2.2.1 STANLEY CONSULTANTS DATA

In their May 1978 Stage 2 Section 111 Study on the impact of the federal navigation structures, Stanley Consultants compiled bathymetric data to analyze the nearshore change in the bottom profiles to the east of Vermilion Harbor. The location of the individual profile lines used in Stanley Consultant's comparison is shown in Figure 2.2.1. The volumetric change in the nearshore zone follows in Figure 2.2.2 for various time intervals from 1968 to 1977 both before and after the breakwater construction of 1973.

The data shows that during the period 1968 to 1971, a general erosional trend existed from the harbor east pier to the eastern edge of Linwood beach. The erosion on Lagoons Beach was generally less severe than on Linwood, but in no instance did the yearly rate exceed 700 cubic yards/yr. On Nakomis Beach (approx. station 28 to 38) an accretional trend is evident varying from 150 cy/yr. at sta 28 to 550 cy/yr at sta 32 to 900 cy/yr at sta 36 (off graph).

This trend of erosion adjacent to the east pier was radically changed during the 1971-1973 period. Updrift erosion on Linwood and Nakomis Beaches from Station 20 east was caused by the increasing lake levels (see figure 2.1.1) of that period. The Lagoons and western most reaches of Linwood Beach benefited from this updrift erosion showing major profile accretion directly east of the east pier. The largest estimated accretion of 7500 cy/yr occurred at station 4 whereas the largest estimated erosion of 4300 cy/yr occurred at station 30. Note that this occurrence of significant accretion at the east pier began prior to the construction of the offshore breakwater and can be attri-

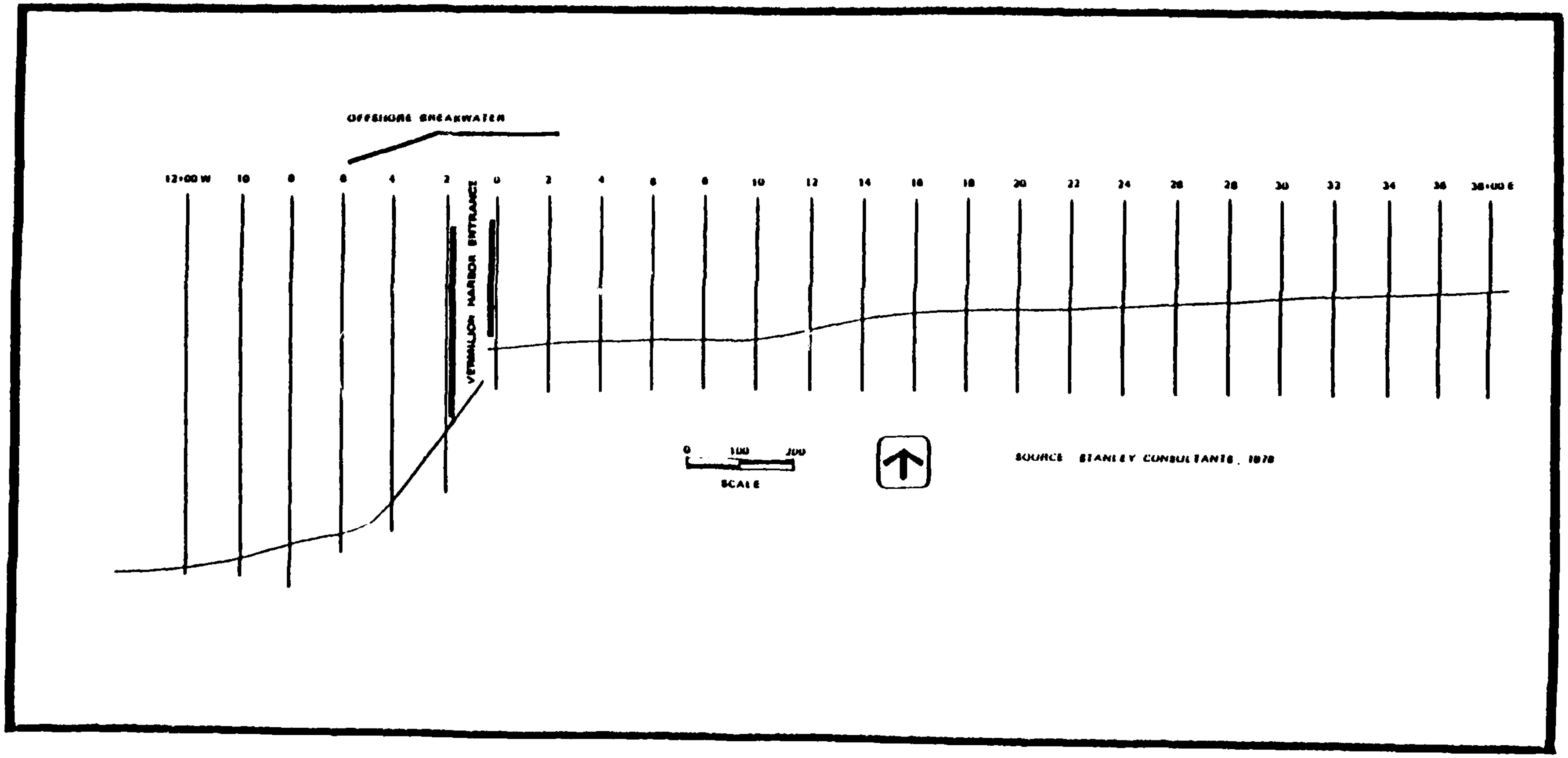


Figure 2.2.1
PROFILE LINES, BATHYMETRIC CHANGE ANALYSIS

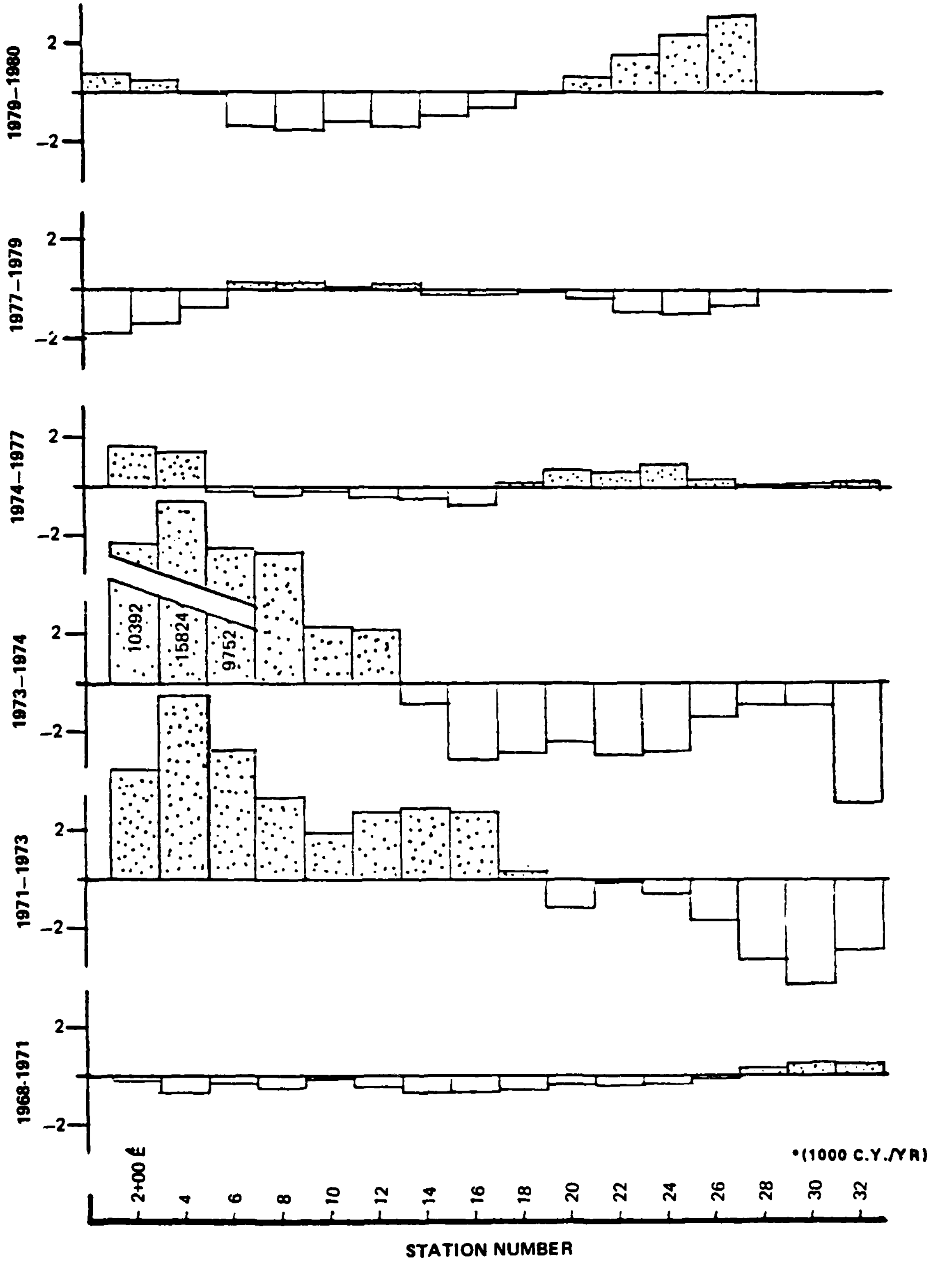


Figure 2.2.2 **NEARSHORE VOLUMETRIC CHANGE*, VERMILLION, OHIO**

buted to high lake levels and predominance of storms from the north through easterly directions during that period.

The 1973-1974 period ran from April 1973 thru July 1974. Since the offshore breakwater construction was begun in the summer of 1973 and was completed in December 1973 this period includes pre, during, and post-breakwater influences. Therefore the 1973-74 comparisons will be considered as a transition period.

The data for this transition period indicates a continued re-adjustment of the offshore profile towards accretion at the east pier and additional erosion along Linwood and Nakomis Beaches. The annual rate at which sediment accumulated east of the east pier exceeded that of the 1971-1973 period by a factor of two. The estimated accretion at station 4 had increased to 15,800 cy/yr from 7500 cy/yr, the area of erosion had increased extending from station 14 to the east, and the levels of erosion along Linwood and Nakomis Beach had increased significantly with high rates on Nakomis of 4800 and 5100 cy/yr at stations 32 and 34 respectively.

Since the 73-74 period includes only 7 months of post-breakwater influence, the higher levels of accretion along Lagoons and erosion along Linwood and Nakomis Beaches cannot be solely attributed to the presence of the breakwater. It is impossible with the data at hand to discern just how this increase should be distributed among the three most probable causes: high lake levels, predominance of storms from the northeast, and the offshore breakwater.

The profile adjustment precipitated by the above mentioned causes appeared to be short-lived, and the period 1974-1977 saw a dramatic decrease in the amount of profile accretion east of the east harbor pier. This implies that the beach required about 2 years to stabilize following breakwater construction. Similarly, the trend towards erosion at Linwood Beach during the early 1970's subsided, and mild accretion predominated during the 1974-1977

period along the eastern portion of the beach. Accretion adjacent to the east pier at stations 2 and 4 averaged about 1500 cy/yr, a ten fold drop in comparison to the 1973-74 period. Slight erosion dominates from station 6 on Lagoons Beach to station 16 on Linwood Beach with levels varying from 150 to 700 cy/yr Accretion is evident east of station 18 with levels of about 700 cy/yr along Linwood Beach and 70 to 270 cy/yr along Nakomis Beach.

On Figure 2.2.3 the Stanley, Inc. data for the periods 1968-71 and 1971-73 have been combined (note scale change) to portray a pre-breakwater period trend. Also, the 1974-77 data is shown as part of the post-breakwater period. The 1973-74 period is omitted because of its transitional nature. In the pre-breakwater period (1968-1973), moderate accretion was evident for 1600 feet to the east of the harbor piers. Mild erosion persisted to the east of this section. The post-breakwater period (1974-77) still shows accretion adjacent to the east pier but only extending 600 feet to the east. From Station 6 to 18, mild erosion is evident with rates averaging less than 1100 cubic yards per year. This area was accreting at rates of 1000 to 3000 cubic yards per year in the pre-breakwater period. From station 18 east, the trend reverts back to mild accretion in the same area which was eroding during the pre-breakwater period.

Data shown on Figure 2.2.3 was developed from combined Corps and Stanley, Inc. data bases shown in appendix D to this report.

2.2.2 CORPS OF ENGINEERS DATA

In order that the volumetric changes for the shores east of Vermilion Harbor presented in the May 1978 Stanley Report could be updated for this study, the Corps of Engineers, Buffalo District, conducted two bathymetric surveys in June, 1979 and August, 1980. These surveys covered the shoreline area for 2800 feet east of the east pier at Vermilion Harbor including the Lagoons and Linwood Beaches but not Nakomis Beach.

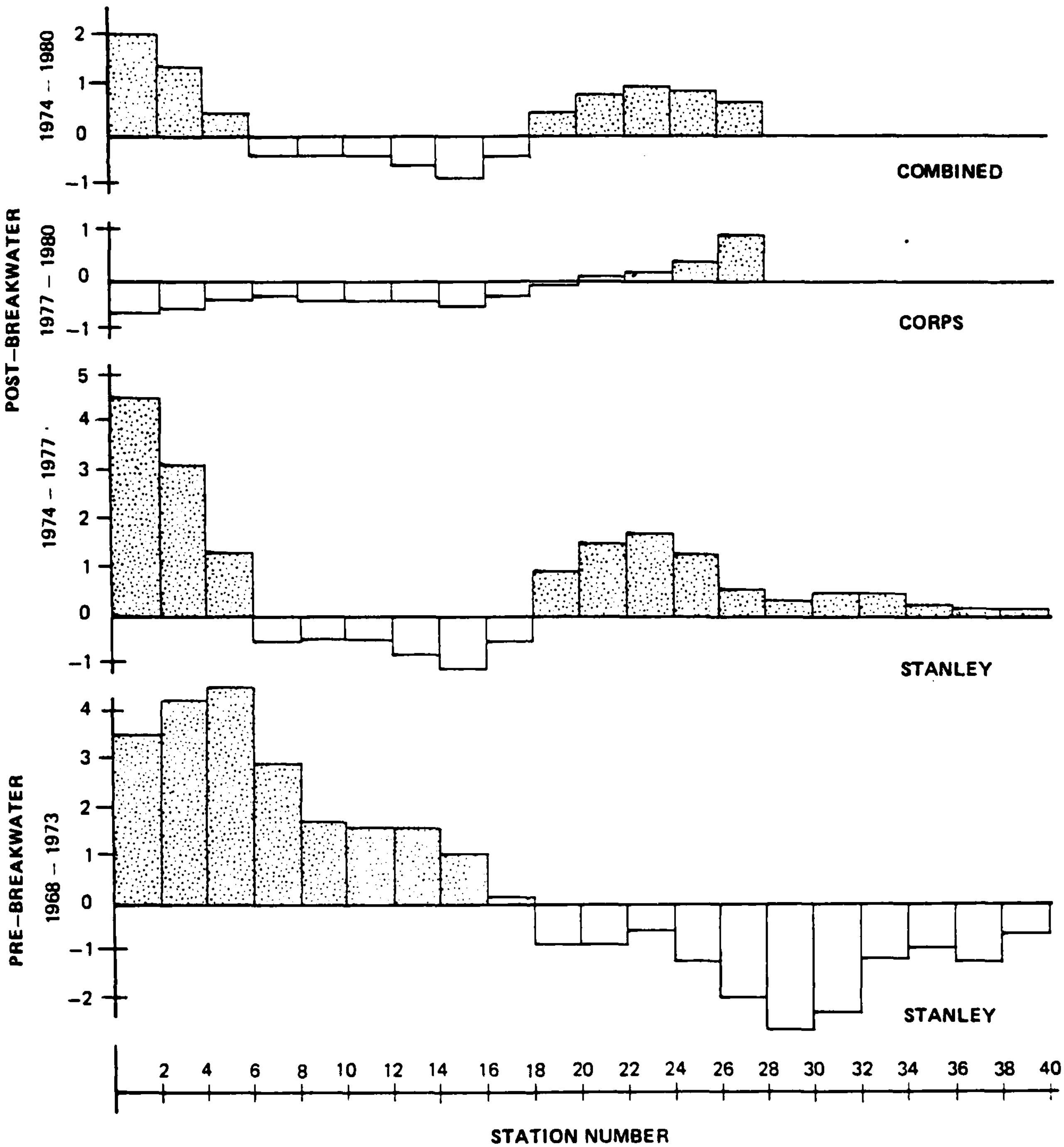


Figure 2.2.3 LONG TERM VOLUMETRIC CHANGE, VERMILION, OHIO (THOUSAND CUBIC YARDS PER YEAR)

The average end method was used to estimate the volume change in any particular shoreline segment. Figure 2.2.2 presents the volumetric change between October 1977 and June 1979 and between June 1979 and August 1980 based on the Corps bathymetric surveys.

The data shows that in the period 1977 to 1979 erosion took place in the Lagoons Beach area adjacent to the east pier. The magnitude of erosion at stations 2 and 4 was about 1500 cy/yr in direct opporition to the accretion estimated in the 1974-1977 period. It should be noted that part of this recorded loss may be due to a May 1979 sand pumping demonstration program wherein sand was pumped from the area between stations 0 to 2 and placed at about Station 28. Small levels of accretion (100 to 300 cy/yr) are observed from station 6 to station 14 on the western end of Linwood Beach, an area which suffered small levels of erosion during the prior period. From station 14 to the eastern extent of Linwood Beach erosion is estimated at levels from 60 to 990 cy/yr in an area which showed moderate (180 to 960 cy/yr) accretion during the previous period. It appears that some of the beach material in the fillet has been redistributed to the east by wave activity.

In the period 1979 to 1980 the data reveals moderate accretion (600-700 cy/yr) from the east pier to station 4. Erosion is prevalent from station 4 to station 20 thence accretion from station 20 to 28. This pattern is similar to that observed during the 1974-1977 period although the levels of erosion and accretion are higher in this most recent period. This pattern indicates erosion at the center of Lagoons - Linwood - Nakomis Beach system with redistribution of material both east and west.

Figure 2.2.3 shows the combined 1977 to 1980 Corps data in a post-breakwater period in contrast to the Stanley 1974-1977 data just following breakwater construction. The 1977-80 data shows a big difference in the trend toward fillet accretion adjacent to the east pier with erosion prevailing from the east pier to station 20 generally reducing with distance to the east. After station 20, accretion dominates with increasing levels toward the east.

The post-breakwater period is broken up into two periods because of the different data sources but these charts point out an important change in trends after 1977. In the 77-80 period, erosion prevails from the east harbor pier to station 20, but accretion occurs from station 20 to 28. In contrast, the pre-breakwater chart for 1968-73 shows accretion for stations 0 to 18 and erosion for stations 18 to 40. By combining the Corps and Stanley data (see Appendix D) a bar chart is produced for the entire post-breakwater period 1974 to 1980 as shown on Figure 2.2.3. It may be noted that the high accretion rates adjacent to the east pier in the post-breakwater, high lake level period 1974-77 dominate the slight erosion trend indicated by the 1977-80 chart.

In a comparison of the 6 years (1974-1980) since breakwater construction vs the 5 years (1968-1973) prior to breakwater construction, the accretion trend adjacent to the east pier has decreased to about half the pre-breakwater levels. Also, the extent of accretion along Lagoons Beach has decreased and the eastern segment of Lagoons Beach indicates an eroding trend. The western reach (station 9 to 18) of Linwood Beach which was accreting in the pre-breakwater period now shows erosion while the eastern reach (station 18 thru 28) which was eroding during the pre-breakwater period now indicates accretion.

It is felt that a more valid comparison of pre and post breakwater volumetric change requires longer periods of data analysis. Especially in the post-breakwater period 1974-80 it can be seen that the changes taking place in the 1973-74-75 time frame bias the post-breakwater trend in comparison to the latest trend shown in the 77-80 time frame. Therefore any attempt to determine the effects of the breakwater on the shoreline based on volumetric change data alone would be inconclusive.

3.0 RESULTS OF THE AERIAL PHOTO ANALYSIS

3.1 SPECIFIC PHOTO COVERAGE

The aerial photo analysis performed in this study was undertaken for the reach bounded by the east pier of Vermilion Harbor to the eastern end of Nakomis Beach. This study area encompasses Lagoons, Linwood, and Nakomis Beaches. Aerial photos for the Sept. 1980 study were chosen to determine shoreline position at intervals that averaged six years in duration. Aerial photos selected for additional analysis in this study were chosen by the Corps of Engineers to augment those in the earlier study especially around the critical period of construction of the breakwater in 1973 and 1974. Also, the data base was extended as much as possible by the addition of a September 1980 photo set.

The combined aerial photography listing is presented in Table 1. The years 1950, 58, 64, 71, 77 and 79 were analyzed in the September 1980 study; the remaining years were analyzed for this study.

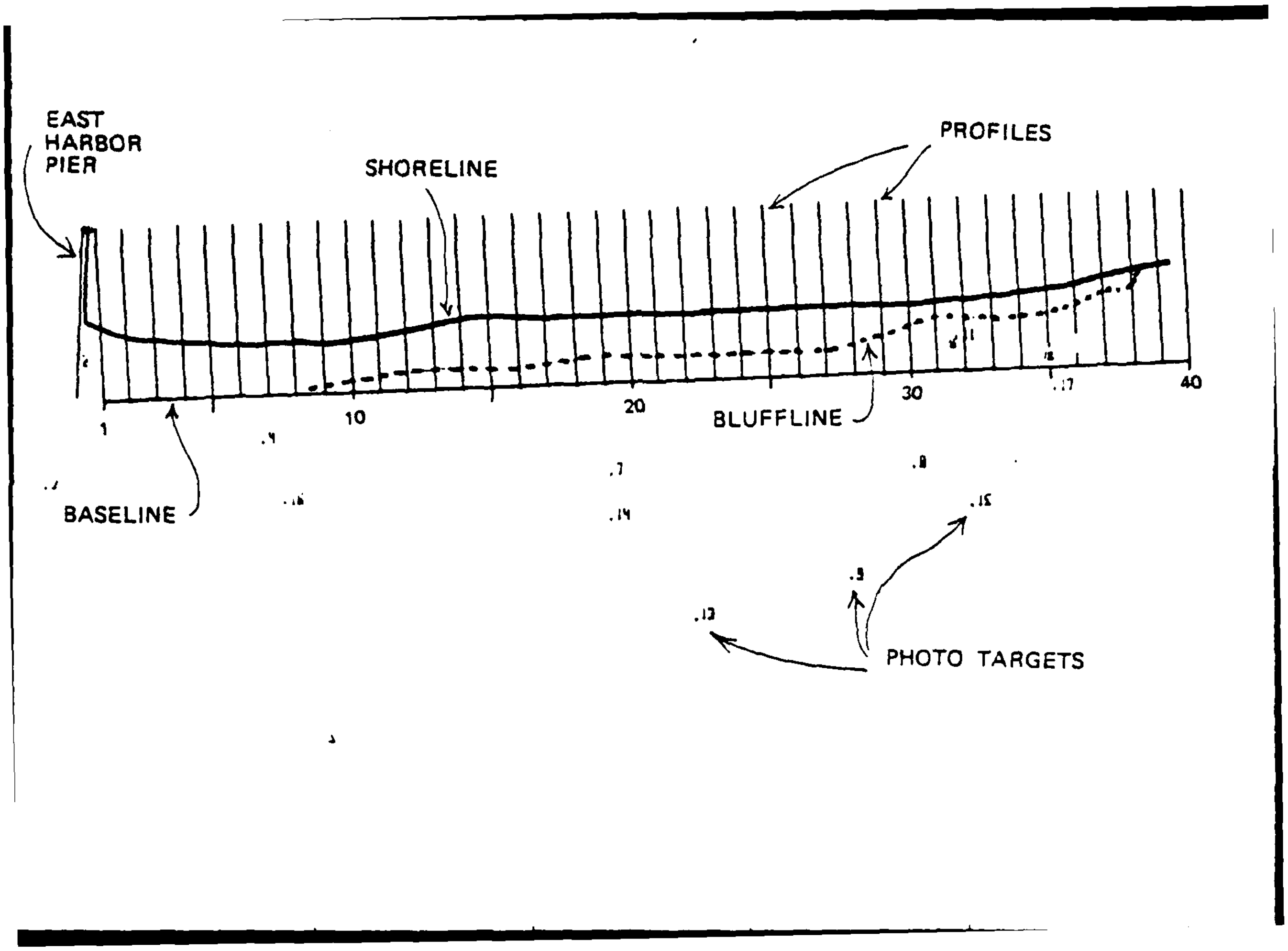
3.2 SPECIFIC BASELINE LAYOUT

The placement of shore-parallel baselines along the study reach serves to demarcate the origin of the shoreline position measurement system. The result of the electronic digitization procedure is the computed intersection of a specific shoreline with each profile emanating perpendicularly from the baseline. In the photo analysis, consecutive profiles were distributed along the baseline at 100 foot intervals.

Figure 3.2.1 illustrates the baseline position and orientation and profile locations for the study area. The first profile is positioned slightly east of the east harbor jetty. Because the length of the beach to the east of the harbor varied over the

Table 1: Aerial Photograph Listing

YEAR	MONTH	PHOTO SCALE	LAKE LEVEL	
			IGLD (1955)	RELATIVE TO LWD (568.6')
1948	3	1"=367'	571.1	+2.5
1950	11	1"=400'	570.2	+1.6
1958	7	1"=400'	570.1	+1.5
1964	5	1"=400'	569.7	+1.1
1968	4	1"=400'	571.1	+2.5
1971	5	1"=400'	571.7	+3.1
1973	4	1"=400'	573.2	+4.6
1974	7	1"=400'	573.2	+4.6
1977	3	1"=400'	570.6	+2.0
1978	4	1"=400'	572.3	+3.7
1979	4	1"=400'	571.6	+3.0
1980	9	1"=400'	572.4	+3.8


EAST
HARBOR
PIER
SHORELINE
PROFILES
1
10
20
30
40
BLUFFLINE
BASELINE
PHOTO TARGETS

1948-1980 study, the total number of profiles varied from 31 to 38. The position of the shoreline relative to the origin of the baseline at each profile for each year is presented in Appendix A for those years covered in the September 1980 study and in Appendix B for those years analyzed for this study.

3.3. SHORELINE POSITIONS

The digitized shoreline taken from the aerial photographs is the still water level at the time of the photo. In order to relate all the shorelines to a single vertical datum, the shoreline data files must be corrected using a vertical datum correction and beach slope data.

Depending upon the length of record spanned by the data base, the kind of data bases, and the location of the study, up to three vertical corrections may be considered:

(1) Survey Datum Correction
(2) Lake Level Correction
(3) Subsidence Correction

For this study, corrections due to tide and subsidence were considered negligible. The corrections for survey datum shifts and lake level fluctuations are used to raise or lower the shoreline along the sloping beach profile to a new horizontal position. The survey datum correction is used, for example, to change a shoreline digitized from a map showing a mean high water shoreline to the low water shoreline using the beach slope and the vertical distance between mean high water and mean low water.

The lake level correction is used to correct shorelines digitized from aerial photos to a common level. Lake levels at the time of the photos are obtained from historical records. All photos were reduced to the mean water level of Lake Erie (570.4 feet, International Great Lakes Datum, 1955).

Beach slopes at intervals along the study area are required in order to make the vertical datum corrections. These are usually determined from whatever surveyed profiles are available and are examined carefully to render a judgement that they are reasonable and that no sharp anomalies are represented. Usually, the beach slope, once determined, is used for all vertical corrections at that specific profile line. Beach slope data for the Vermilion area were obtained from the Corps of Engineers, Buffalo District.

The corrected shoreline positions as determined by aerial photographic analysis are presented in Appendices A and B for the September 1980 study data base and this May 1981 study data base respectively. Figure 3.3.1 shows the location of the 1948, 1973 and 1980 shorelines with respect to the harbor entrance structures and the chosen baseline.

Recognizing that the locations of these shorelines represent three snapshots in time, the obvious feature along Lagoons Beach is the growth of the fillet adjoining the east pier from 1973 to 1980; whereas, there was little net change indicated for the period 1948 to 1973. Along Linwood Beach erosion is evident on a continual basis from 1948 to 1980 except on the eastern most stretches of the beach where some reversal is evident in the 1973 to 1980 period. Reversal of the erosional trend is also evident on Nakomis where no beach was observed in 1973 but was again evident in 1980 aerial photographs.

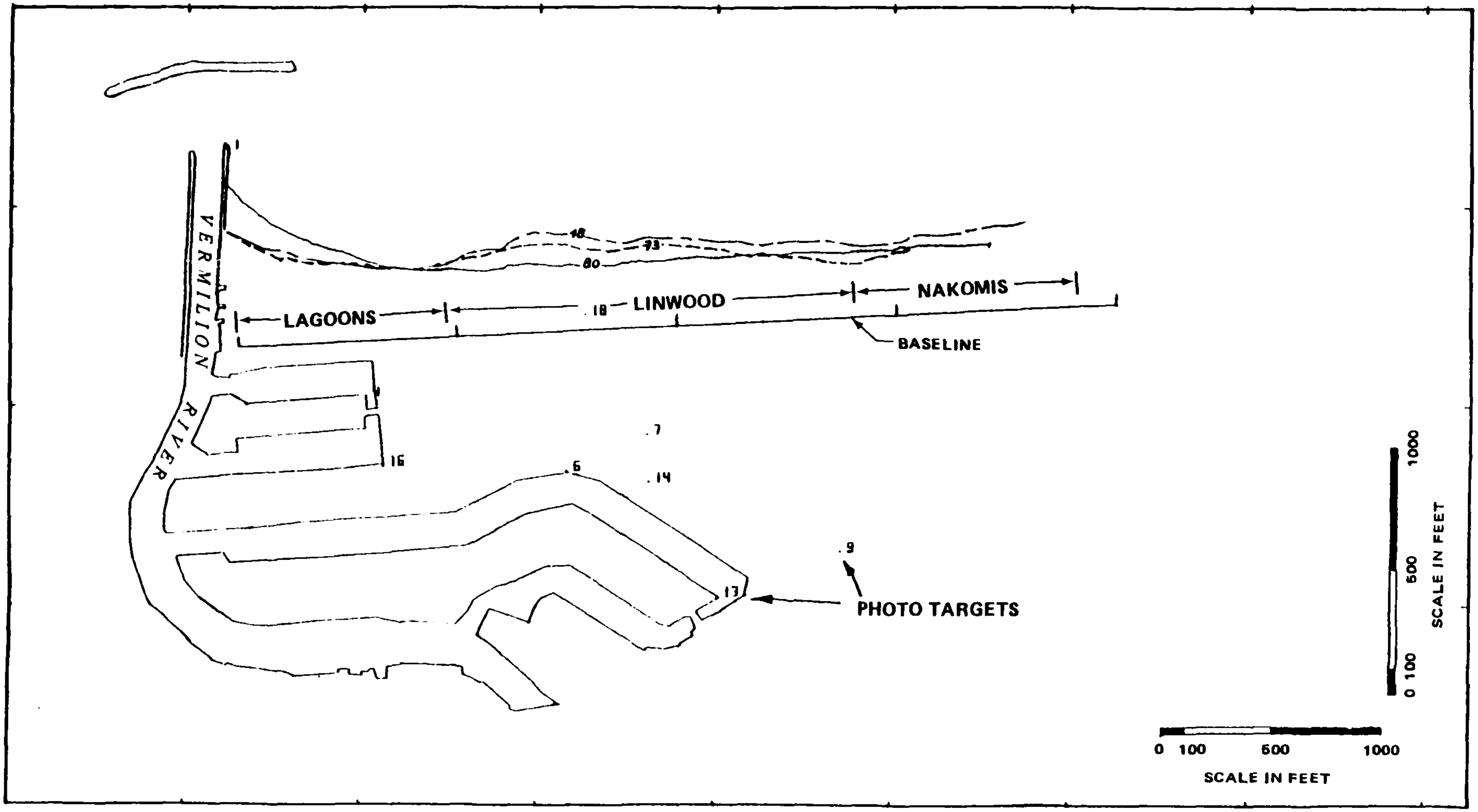


Figure 3.3.1 SHORELINE LOCATIONS EAST OF VERMILION HARBOR, OHIO

3.4 SHORELINE CHANGE RATES

Shoreline change rate data are presented in Appendices A and B for the two data bases studied. In Appendix A the shoreline change rate at each profile is included for the periods 1950 - 1958, 1958-1964, 1964-1971, 1971-1977, and 1977-1979. In Appendix B the change rate at each profile is included for the periods 1948-1968, 1968-1973, 1973-1974, 1974-1978, and 1978-1980.

For the purpose of this study, the two data bases were combined so that a continuous chronological picture of shoreline change could be obtained. In Appendices A and B the location of the corrected shorelines (with reference to a common baseline) are presented for both data sets. By comparing the corrected shoreline location for 1948 (from Appendix B) to that of 1950 (from Appendix A) and dividing the distance between the two by the time lapse, one can obtain the change rate for successive years even though they appear in different data files. This procedure must be repeated at each profile to obtain the change rate curves shown later in this section.

3.4.1 SHORELINE CHANGE RATE FOR CONSECUTIVE TIME PERIODS

<u>1948-1950</u>

Lake level remained close to mean lake stage during this period. This period is characterized by accretion along Lagoons and the eastern reach of Linwood Beach while the western portion (profile 13 thru 20) of Linwood and Nakomis Beaches are eroding. See Figure 3.4.1. The change rate curve appears to be symmetrical about profile 16 indicating erosion in the center of the beach system with accretion at either end but, the area under the accretion curves is much greater than that under the erosion curve, suggesting a net gain in beach material within the system.

<u>1950-1958</u>

During this period, lake levels were quite high in the early 50's

and reduced gradually 2 to 3 feet lower by 1958 to levels below mean lake stage. The drop in lake level most likely lessened the erosion trend shown on Figure 3.4.1 from what it might have been had the period of study ended in 1953 or 54. In any event the shoreline change rate curve shows erosion rates of 5 ft/yr or less throughout the study shoreline except for a small portion of Lagoons (profiles 6 to 8) which shows an accretion rate of 1 ft/yr or less.

1958-1964

During this time, lake levels were dropping to the lowest levels recorded during the study period. This period is charaterized by accretion along Lagoons and Linwood Beach up to profile 16 and erosion from that point eastward. The change rate curve shown on Figure 3.4.2 seems to be somewhat symmetrical about profile 16 with approximately equal areas of accretion and erosion to the east and west of that point.

1964-1968

This was a period of rising lake levels during which the shoreline experienced erosion along Lagoons and the eastern portions of Linwood Beach while Nakomis and the remainder of Linwood Beach showed moderate levels of accretion. See Figure 3.4.2. Other than the erosion along Linwood Beach between profiles 18 and 26 this shoreline change rate curve would be similar in trend to that of the 1958 to 1964 period but with smaller magnitudes of change rate.

1968-1971

During this period the lake level continued to rise. The shoreline change rate curve for this period is shown on Figure 3.4.3. It shows erosion throughout the study shoreline at an average rate of 10 ft/yr. The erosion is an expected result due to rising lake levels, however the uniformity of erosion along the entire study shoreline suggests no predominant storm activity during this period.

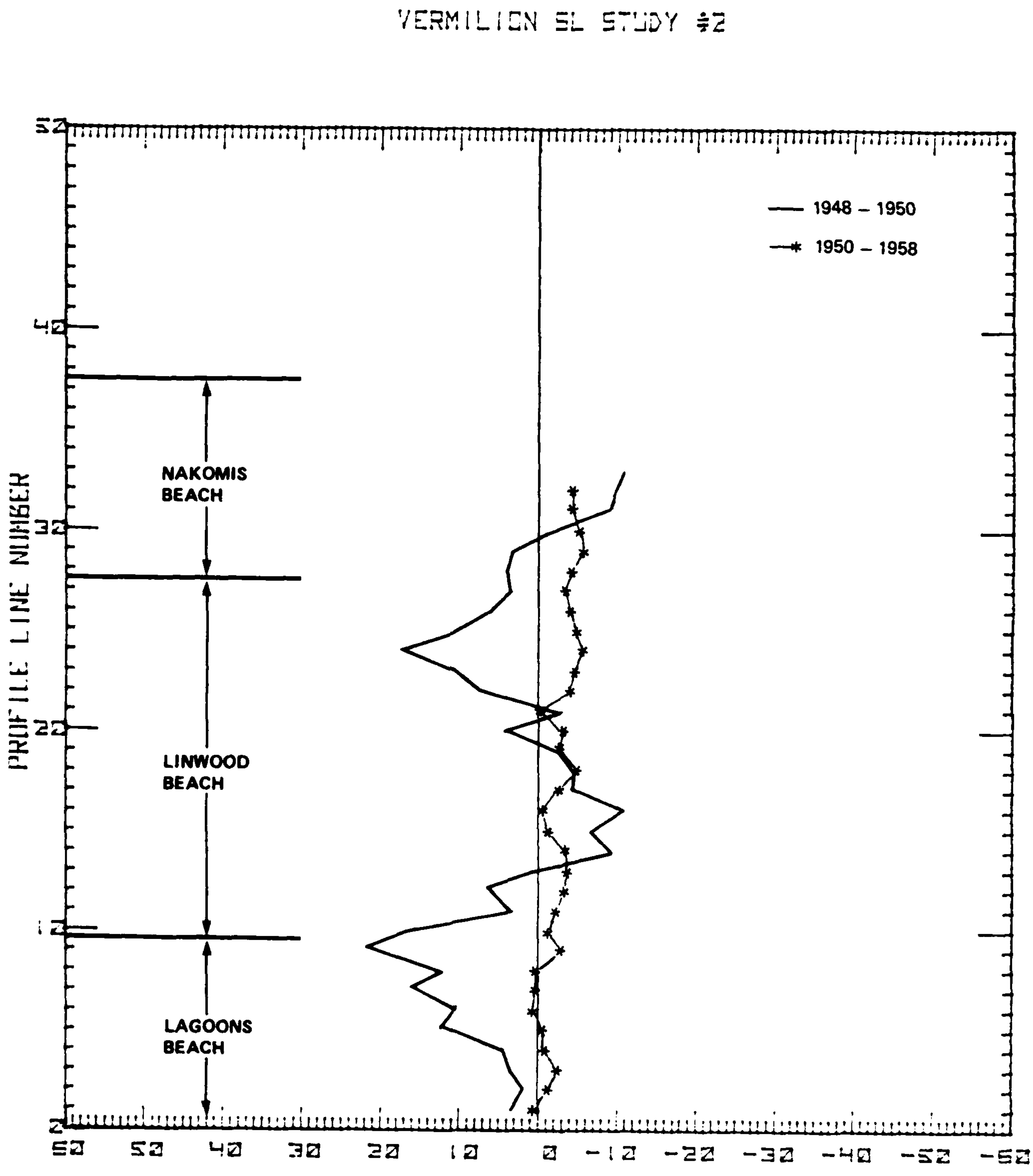


Figure 3.4.1 SHORELINE CHANGE RATE (FT/YR) USING CORRECTED SHORELINE

VERMILION SL STUDY #2

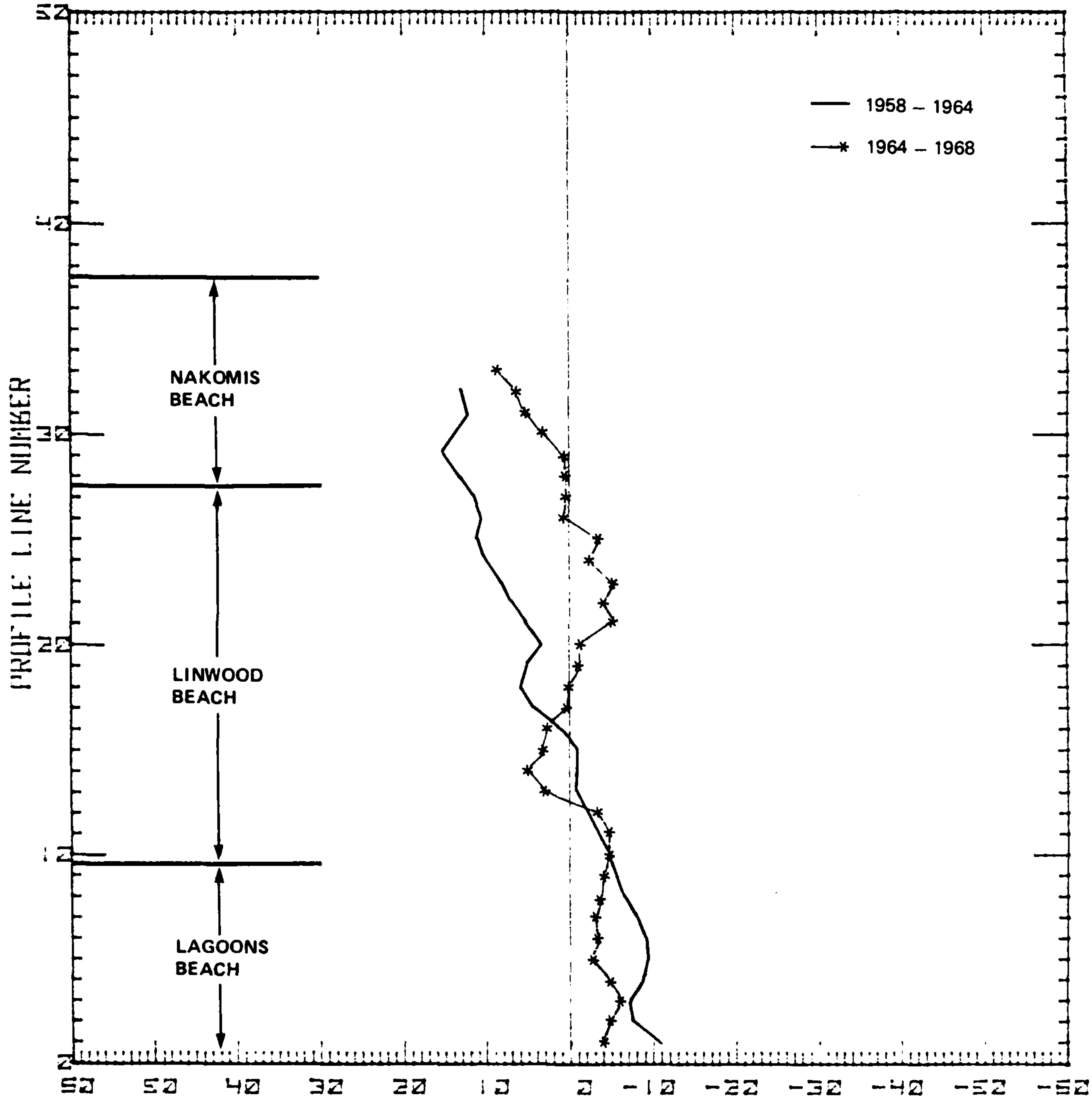


Figure 3.4.2 SHORELINE CHANGE RATE (FT/YR)
USING CORRECTED SHORELINE

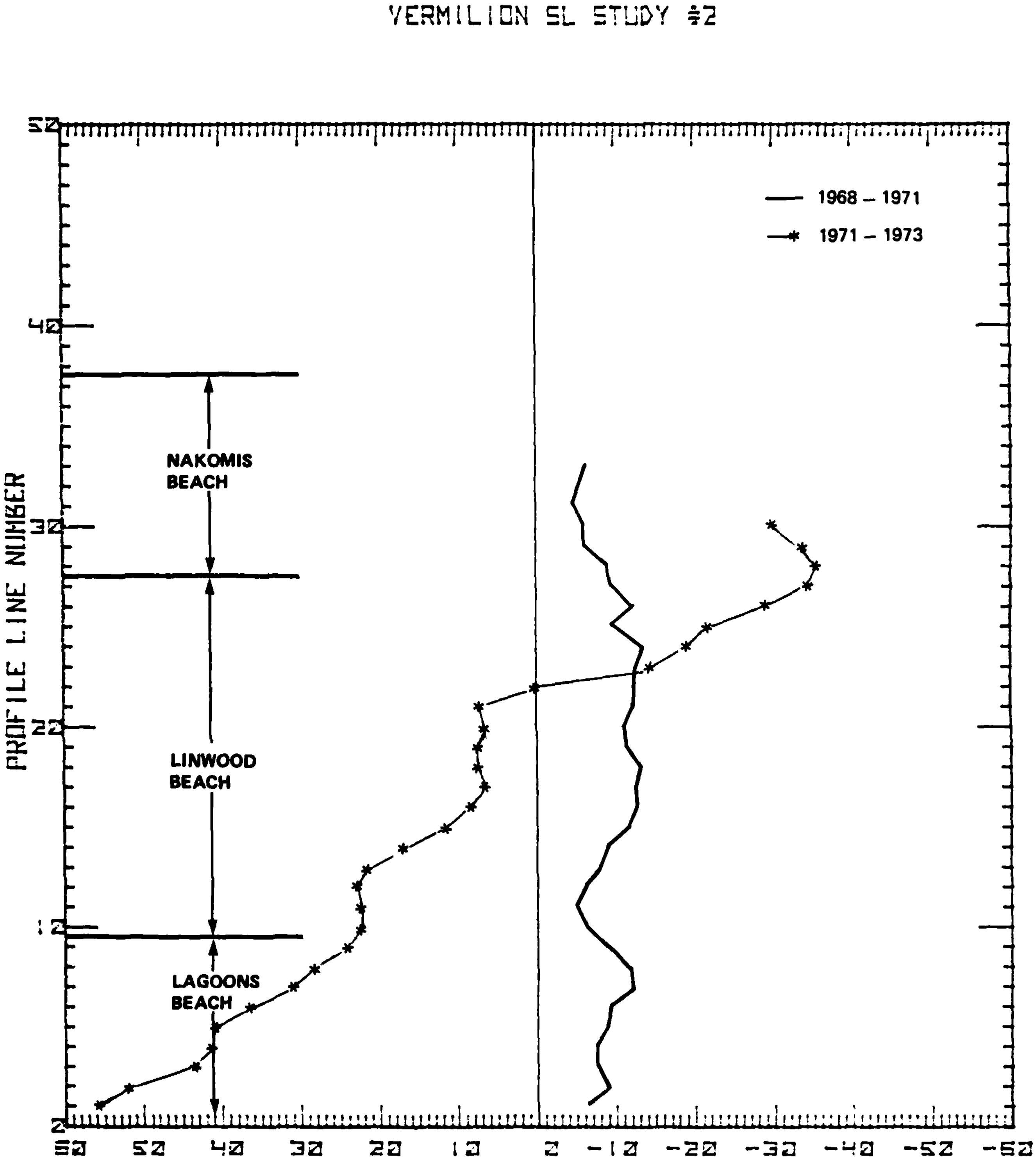


Figure 3.4.3 SHORELINE CHANGE RATE (FT/YR) USING CORRECTED SHORELINE

1971-1973

It is during this period that lake levels were the highest ever recorded on Lake Erie. Figure 3.4.3 shows high rates of erosion along Nakomis and the eastern stretches of Linwood Beach. Similarly high rates of accretion are shown for the western stretches of Linwood Beach and high rates of accretion are indicated along Lagoons Beach. This period is prior to breakwater construction and suggests that strong easterly storm predominance coupled with extremely high lake levels has caused these extreme shoreline change rates.

1973-1974

The lake level remained at the highest levels during this period. The shoreline change rate curve for the period 1973-74 is presented on Figure 3.4.4. This curve represents the time period immediately before, during, and after breakwater construction. The curve shows that the entire stretch of Linwood Beach is eroding at rates as high as 40 ft/yr. Lagoons, on the other hand is accreting at high rates of up to 120 ft/yr adjacent to the east pier. This suggests an easterly wave energy dominance during this period which transported littoral materials westward to create the fillet at the east pier. Also during this period the breakwater was constructed and, as in so many other documented cases, the shoreline reacted to the new conditions.

1974-1977

Lake levels lowered rapidly in the 74-77 period and the shoreline change rate curve shown on Figure 3.4.5 for this period suggests the influence of lower lake levels. Also, the high accretion rates observed during the previous period have diminished to relatively small levels. A portion of Lagoons Beach shows erosion. The entire Linwood Beach sector shows slight erosion during this period. Due to the balanced nature of this curve with accretion indicated at both ends and erosion in the center, no storm direction dominance is suggested for this period.

VERMILION SL STUDY #2

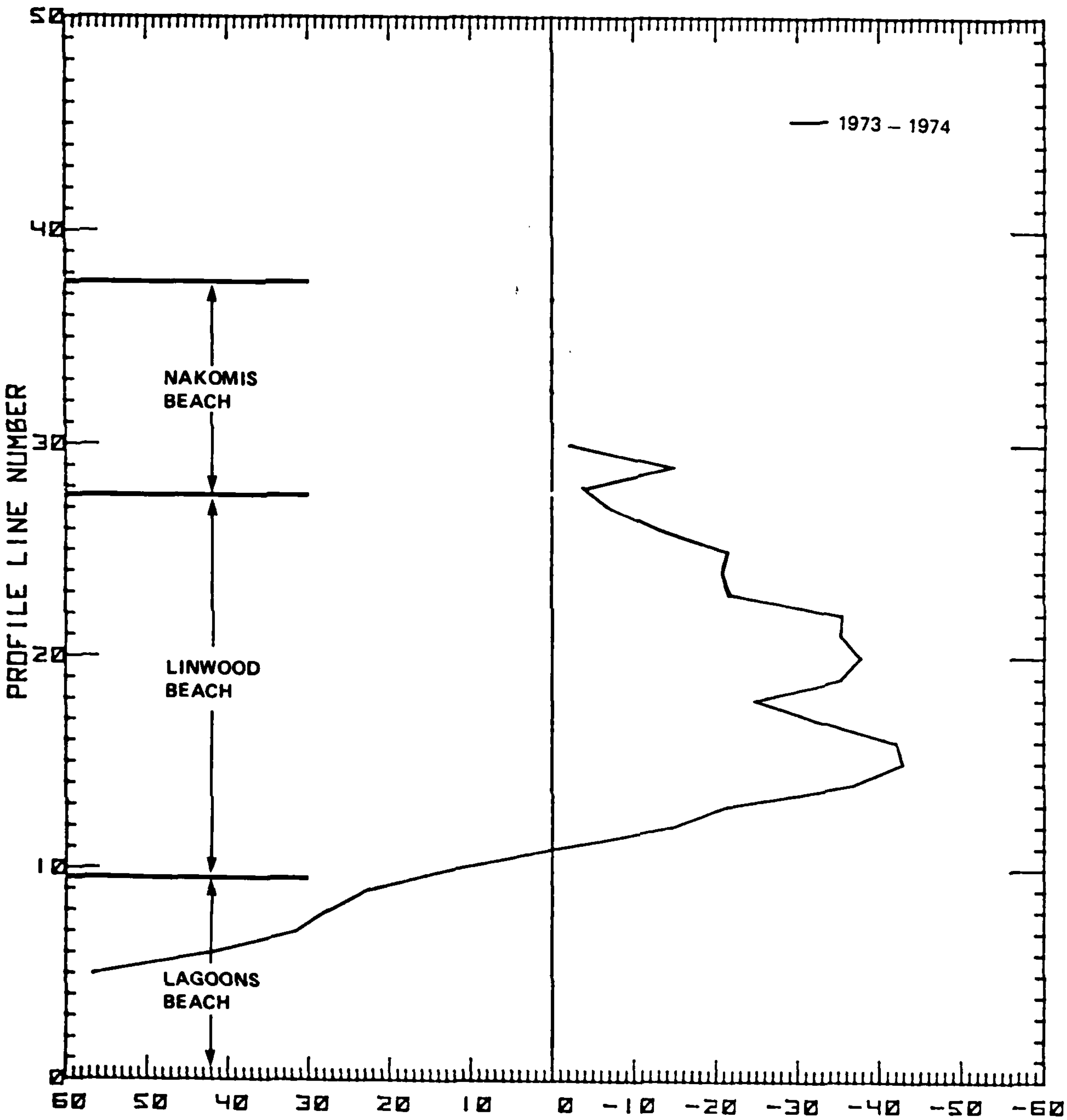


Figure 3.4.4 SHORELINE CHANGE RATE (FT/YR) USING CORRECTED SHORELINE

VERMILION SL STUDY #2

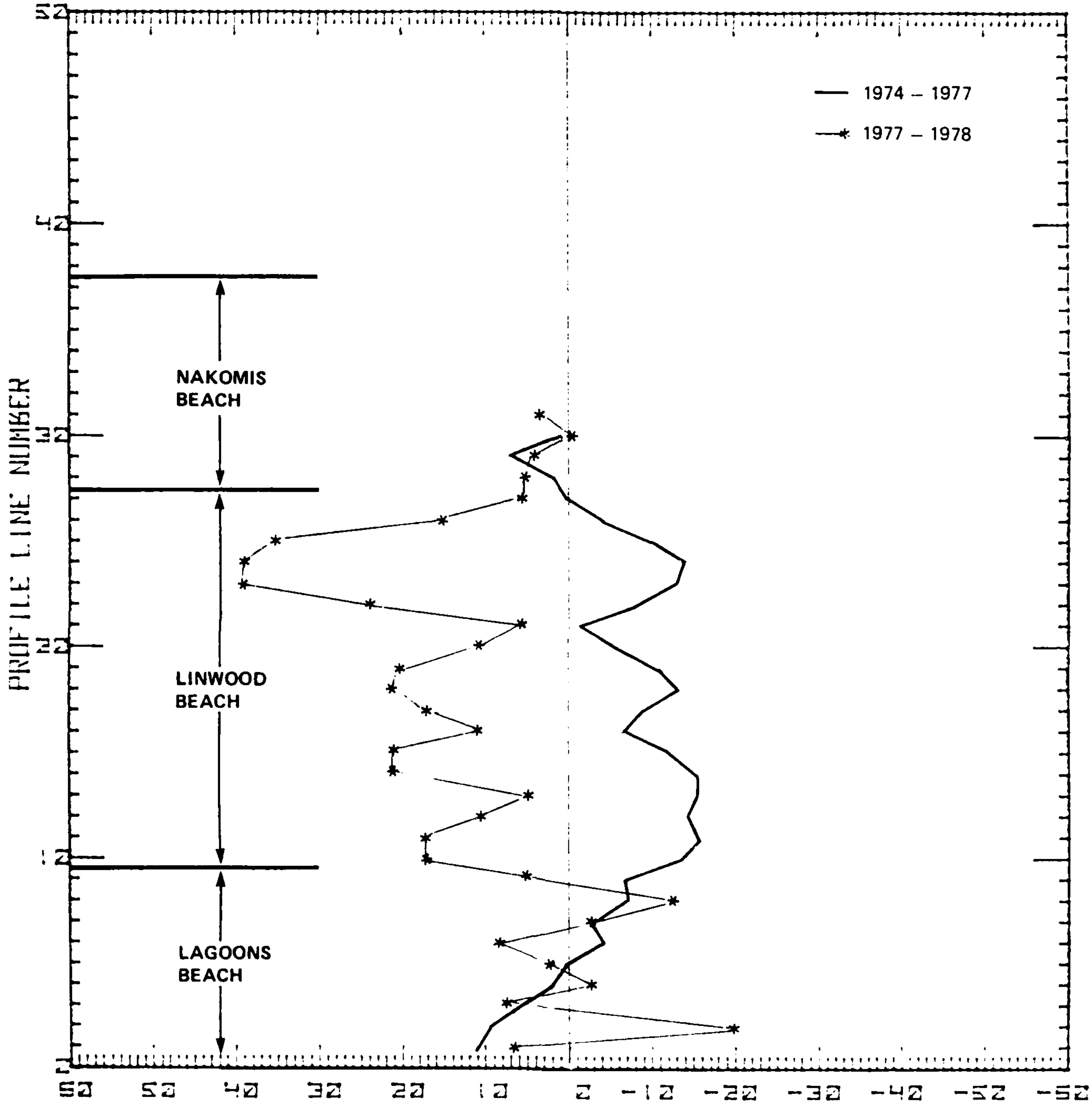


Figure 3.4.5 SHORELINE CHANGE RATE (FT/YR)
USING CORRECTED SHORELINE

1977-1978

During this period the lake level rose almost 2 feet. In this period, as seen on Figure 3.4.5, most of Lagoons Beach is eroding while Linwood and Nakomis Beaches are accreting at substantial levels.

1978-1979

There was a slight reduction in lake level during this period. The trend indicated in the previous one year period has reversed during this period as shown on Figure 3.4.6. Accretion is evident along Lagoons and the western stretches of Linwood Beach. East of profile 17 Linwood and Nakomis Beaches are eroding at moderate change rates.

1979-1980

The lake level had risen slightly during this period in contrast to the slight drop observed during the previous period. For this period the shoreline change rate curve is shown on Figure 3.4.6. It is practically the mirror image of the 1978-79 period curve showing erosion from profile 21 west along Linwood and Lagoons Beaches while east of this point accretion prevailed.

From the foregoing analysis it is evident that major changes in beach configuration have taken place throughout the 1948-1980 study period. The total length of sandy beach has fluctuated from 3,100 feet to 3,800 feet during this time. On four occasions (1958,73, 74,79), the east portion of Nakomis Beach did not exist. The other major beach change has occurred near the east harbor pier along Lagoons Beach where the beach had accreted as much as 300 feet since 1971, due, in part, to the shelter provided this area by the offshore breakwater that was constructed in 1973. The extent of this accretion zone spans the distance from the east pier to a point about 1,000 feet from the pier. The magnitude of this accretion was especially dramatic because Lagoons Beach was at its most landward position of the entire 32 year study period in 1971--just prior to the high water of the 1970's and breakwater construction.

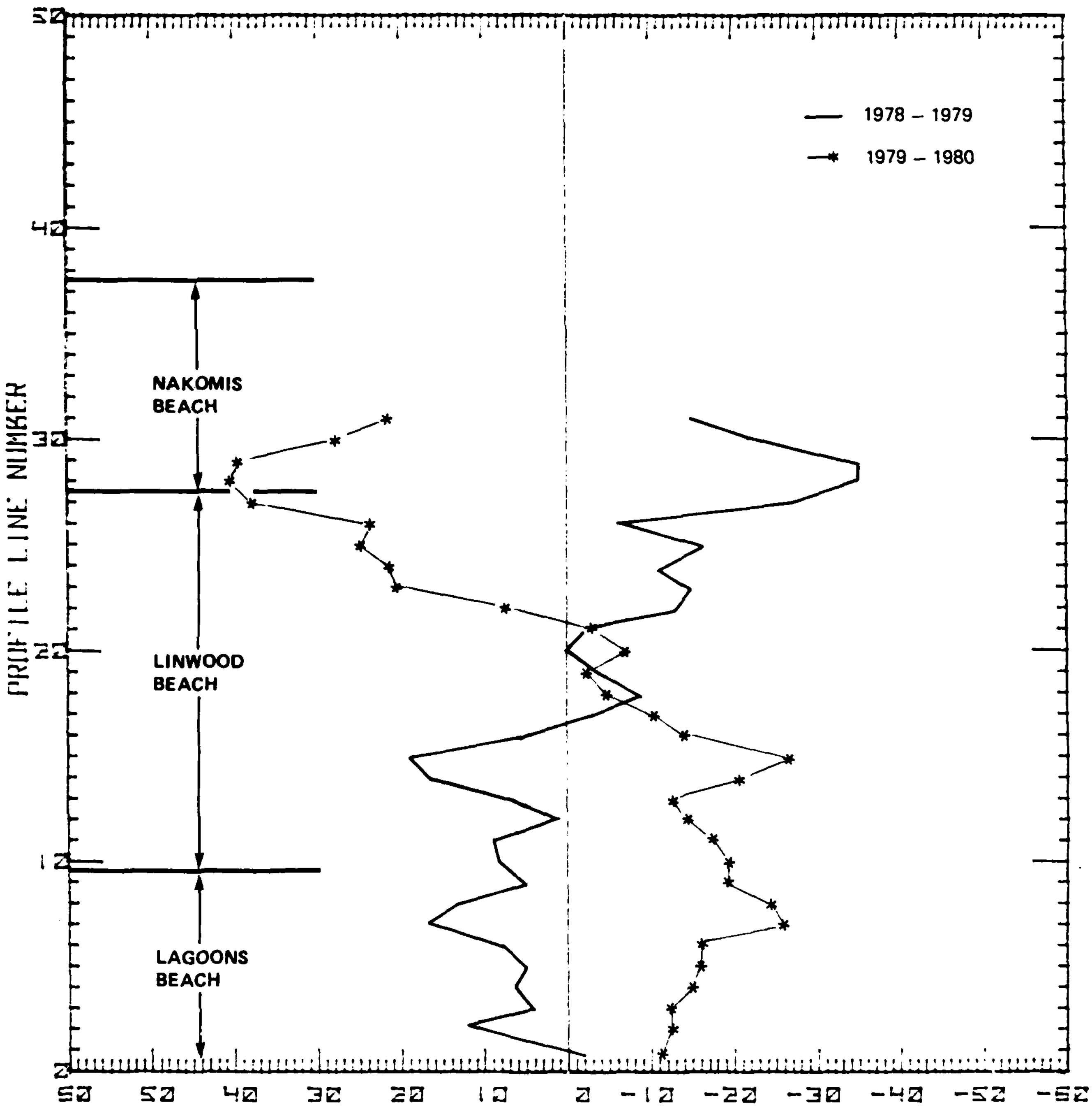


Figure 3.4.6 SHORELINE CHANGE RATE (FT/YR) USING CORRECTED SHORELINE

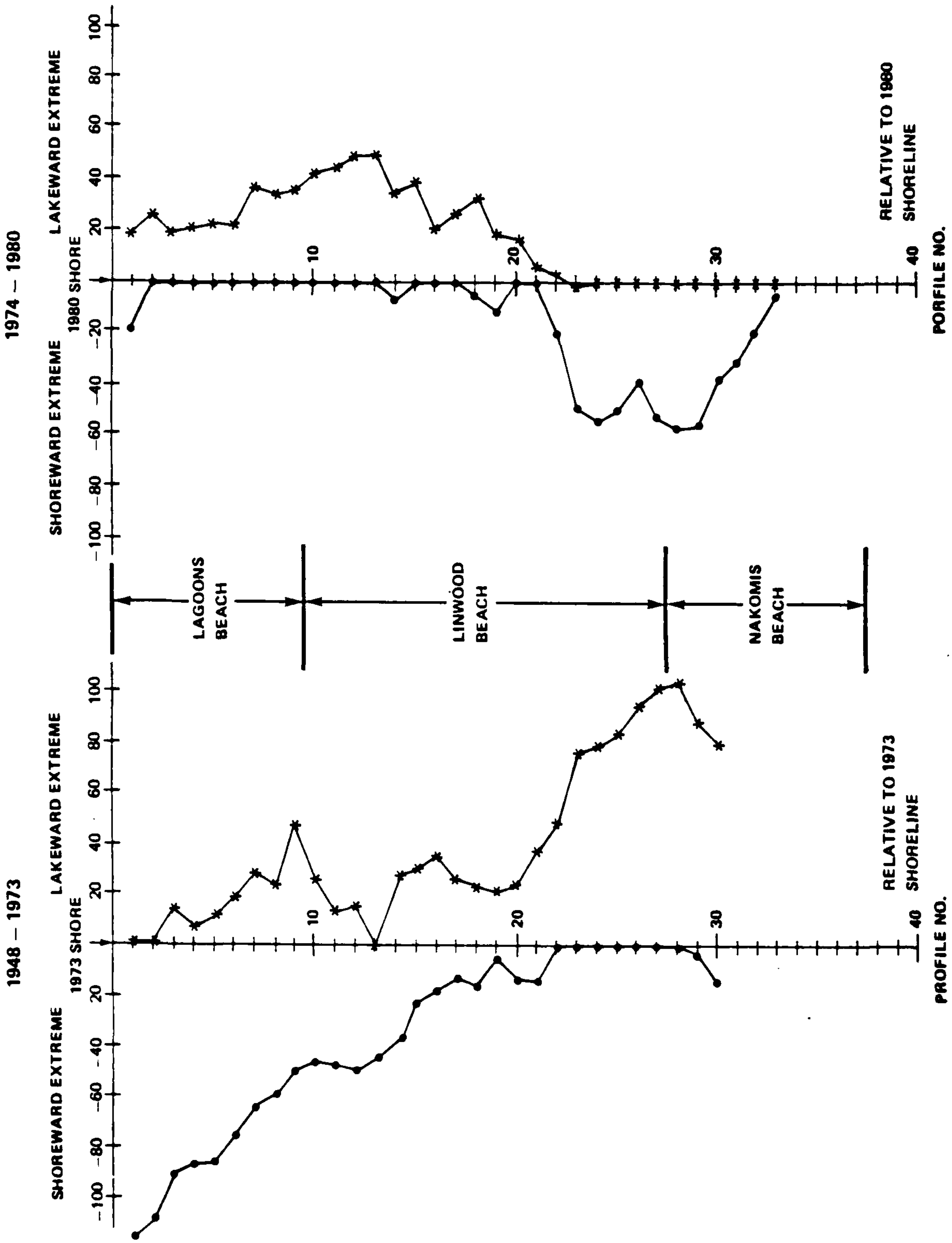
3.5 EXTREME SHORELINE POSITIONS

Figure 3.5.1 shows extreme lakeward and landward positions of the shoreline that occurred during the 1948-1973 pre-breakwater photo period and the 1974-1980 post-breakwater period using the combined data bases from Appendix A & B. The shoreline extremes at each profile are given relative to the 1980 shore for the post period and the 1973 shore for the pre period. This figure represents the "envelope" of past shore positions and at what position the shore exists relative to the lakeward and landward extremes over the period specified. This analysis shows that for the pre-breakwater period 1948-1973, the 1973 shoreline was the most shoreward position of Linwood Beach from profile 22 to 28. This was the worst erosion ever experienced along this piece of shore during that period. Along Lagoons Beach, however, the 1973 shoreline was very close to its most lakeward extreme during the study period.

In the post-breakwater period, Lagoons and the western portion (to profile 21) of Linwood Beach have experienced erosion such that the 1980 shoreline is the most shoreward the shoreline has been during the 1974-1980 period. Also, east of profile 22 on Linwood and Nakomis Beaches the 1980 shoreline is the most lakeward position that the shoreline has been during the 1974-1980 post-breakwater period. This suggests a trend reversal with the stretch of shoreline east of profile 21 accreting and the stretch of shoreline west of profile 21 eroding during the post-breakwater period.

3.6 EXTREME SHORELINE CHANGE RATES

Figure 3.6.1 shows the maximum erosion rate and the maximum accretion rate which has occurred at each profile during the 1948-80 period. These maximums are based upon data reduced in Appendices A & B of this report. Figure 3.6.1 also shows the 1948-1980 average shoreline change rate throughout the study shoreline.



SHORELINE POSITION EXTREMES PRE AND POST PERIODS

Figure 3.5.1

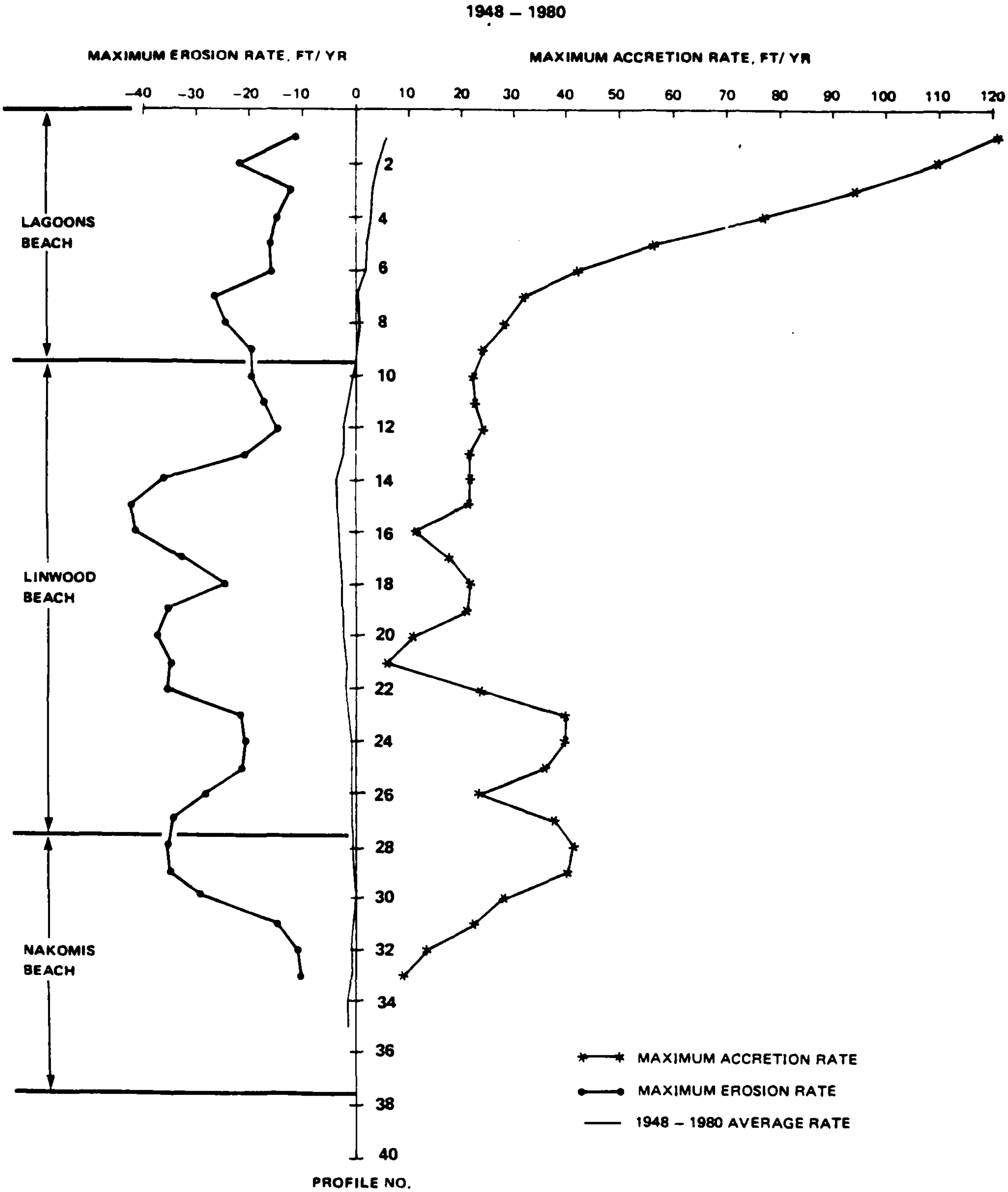


Figure 3.6.1 EXTREME SHORELINE CHANGE RATES

3.7 LONG-TERM SHORELINE COMPARISON

3.7.1 Pre vs Post-Breakwater Comparison

The pre-breakwater period extends from 1948 to 1973 (within the confines of the study data base) and the post-breakwater period extends from 1974 to 1980.

However, as has been previously shown in this report, the short time period representing the post-breakwater period is biased by the effects of extremely high lake levels, and probable dominance by storm activity. It is proposed therefore that the entire 1948-1980 period be used as the basis for comparison with the 1948-1973 pre-breakwater period. By using the entire period it is reasoned that the effects of lake level, storms, and all influential factors will be averaged leaving only the effects of the breakwater when the two periods are compared. See Figure 3.7.1 and Section 3.7.2 for this long-term trend comparison.

3.7.2 Long-term Comparisons

Figure 3.7.1 presents the long-term pre-breakwater trend for the period 1948-1973, and the long-term trend for the entire period covered 1948-1980. Long term trends shown by the 1948-1973 curve reveal small levels of accretion on the order of 1 ft/yr or less along Lagoons Beach with corresponding small levels of erosion on the order of 1 ft/yr along Linwood and Nakomis Beaches.

When the post breakwater period is taken into account, the long-term trends over the period 1948-1980 reveal slight increases in the accretion trend along Lagoons Beach varying from 6 ft/yr adjacent to the east pier to zero, 1000 ft to the east. Between profile 10 and 24 along Linwood Beach the erosional trend has been increased from 1 ft/yr to an average of 2 ft/yr. From profile 24 eastward to profile 31 the erosional trend has diminished from approximately 1 ft/yr to less than ½ ft/yr. As the post-breakwater period lengthens, it is expected that the long-term trend will be closer to that observed in the period 1948-1973.

VERMILION SL STUDY #2

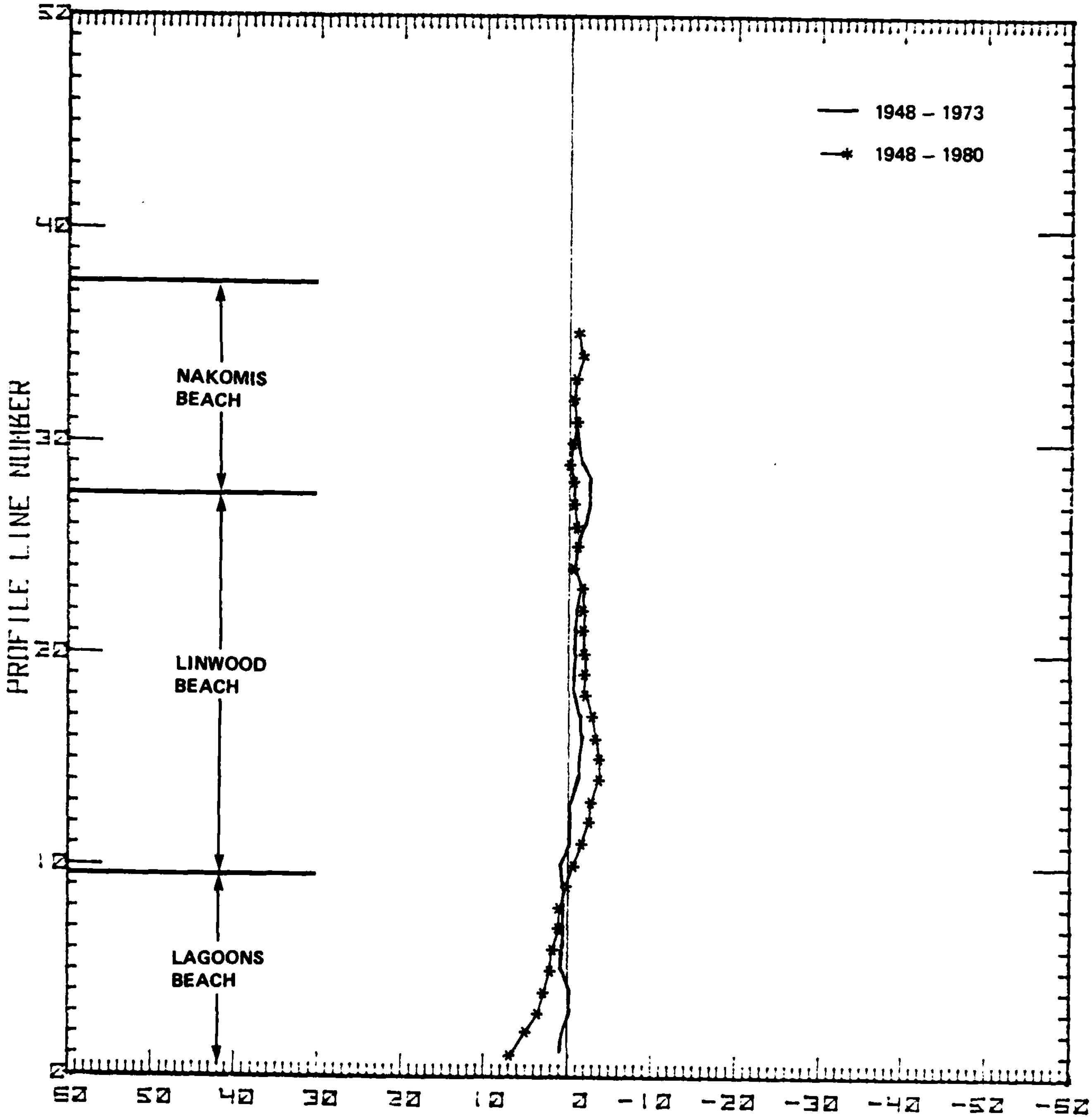


Figure 3.7.1 SHORELINE CHANGE RATE (FT/YR)
USING CORRECTED SHORELINE

3.8 BEACH AREA CHANGES

The shoreline position data (Appendices A and B) was used to determine the long-term trend and the short term fluctuations in the total area of beach lying to the east of Vermilion Harbor. The characteristic change in beach configuration that preceeded and followed the construction of the offshore breakwater in 1973 was accretion near the east pier and accelerated erosion along the central portion of the study reach. Analysis of the beach position data yields the conclusion that a "null point" (a location where no change in beach position occurred) exists when the trend of the pre-breakwater period (1948-1973) is compared with the base period (1948-1980). The location of the "null point" varies with each set of aerial photos, but the average being at Profile 9 (approximately 900 ft from the east pier). This location corresponds approximately with the boundary between Lagoons and Linwood Beaches. To show the fluctuation of beach area along the study shoreline, Table 2 was prepared to show the change in beach area at each of the individual beaches--Lagoons, Linwood, and Nakomis--and also for the entire beach.

The total change figure for each time period shown represents net gains or losses to the system. During periods of high lake level, bluff erosion east of the study limits and westerly littoral material transport adds beach material to the system. Net losses from the system occur as a result of easterly littoral material transport, offshore transport of material and possible losses to the Vermilion Harbor navigation channel although data indicate losses to the navigation channel to be minimal to date. It is interesting to note that over the total 1948-80 period only 0.09 acres of beach were estimated lost from the system. It appears that most of the beach material movement is a result of reorientation of the various beaches within the system according to the predominant wave and storm direction during that time period.

TABLE 2:
BEACH AREA CHANGE (ACRES)

PERIOD	LAGOONS BEACH	LINWOOD BEACH	NAKOMIS BEACH	TOTAL CHANGE
1948 - 1968	-0.94	+0.21	+0.81	+0.08
1968 - 1973	+1.20	-0.92	-0.42	-0.14
1973 - 1974	+1.84	-1.21	-0.05	+0.58
1974 - 1978	+0.11	-0.42	+0.07	-0.24
1978 - 1980	-0.34	-0.16	+0.13	-0.37
		1948-1980 Change --------------		-0.09

3.9 BLUFF CHANGE ANALYSIS

Bluff crest positions measured from aerial photos are considerably more difficult to obtain when the photos are not specifically taken for this purpose. Dense vegetation or incorrect lighting and exposure can easily obscure the bluff edge. In the six new photo sets used in this extended study, only one is judged to be of sufficient quality in locating the bluff crest for using aerial photo techniques, the April 22, 1978 set. Of the remaining photos, the 1980 and 1974 set have too much foliage which completely blanket the bluff, while the black and white 1973, 1968 and 1943 sets have lighting conditions such that a discernible bluff edge is not visible. In the latter sets, the greyish ground color blends with the greyish bluff face so that the crest cannot be easily delineated.

With only one photo set available for new bluff position data, no new bluff analysis is presented as this data would not vary significantly from the 1977 data given in the September 1980 report. It is also felt that any bluff recession on this section of beach is caused by processes other than direct wave impact (see Sept. 1980 report). A large fronting beach would act as an adequate wave buffer. However, wave induced erosion may be a contributing factor on the eastern portion of Nakomis Beach. However the shale bluffs of this area are highly resistent to erosion with rates less than 1 foot per year.

4.0 SHORELINE TRENDS COMPARISON

4.1 VOLUMETRIC SURVEY VS AERIAL PHOTOGRAPHIC SURVEY

The volumetric survey data developed by Stanley Consultants and the Corps of Engineers, Buffalo District as presented in Section 2 of this report will be compared with the shoreline change rate data developed for this and the September 1980 study. Only shoreline trends will be compared here since the volumetric data represents an estimate of cubic yards per year lost or gained at a particular cross-section along the study shoreline. On the other hand, interpretation of aerial photography only represents the change with time, of the position of the line representing the interface of land with the lake. As such, this method does not take into account what happens above or below the waterline. Experience suggests that there should be a definite relationship between the movement of the shoreline and the amount of volume change coincident with the recession or accretion. But, experience also suggests that this relationship may not be the same for all cross-sections along the shoreline especially if they are oriented at different angles to wave incidence or composed of slightly different materials.

No effort was therefore made here to convert the shoreline change data into volumetric change data for direct comparison. Instead, the bar charts (shown on Figure 4.1.1-4.1.3) are compared for areas of accretion or erosion and relative amounts of change. Appendix C contains the data base from which the shoreline change bar charts are drawn. A comparison for each time period follows.

<u>1968-1971</u>

Fairly good agreement can be observed in the volumetric and shoreline change bar charts of Figure 4.1.1 A moderate level of erosion of 10 ft/yr is continuous over the study reach decreasing slightly east of profile 28. The volumetric change bar chart shows a similar trend of modest erosion from the east pier

to station 26. East of this point a small amount of accretion is evident. The areas and relative magnitudes of change in both charts are practically identical.

1971-1973

On the lower half of figure 4.1.1 the volumetric and shoreline change bar charts for the period 1971-1973 are compared. During this period, just prior to breakwater construction, water levels were rising to the highest ever recorded on Lake Erie. High levels of erosion are shown for the eastern stretches of Linwood Beach profiles 22 to 30 increasing with distance to the east. On Lagoons beach and the western portion of Linwood, high levels of accretion are prevalent but the rate decreases with distance east of the east pier. The volumetric change bar chart shows a similar trend except that the inflection point between accretion and erosion is 100-200 ft further west.

1973-1974

This pre and post breakwater period of high lake levels and rapid shoreline adjustment to a new structure is shown on the upper half of Figure 4.1.2. The shoreline change bargraph shows extremely high levels of accretion adjacent to the east pier decreasing rapidly with distance east along Lagoons Beach. Linwood Beach exhibits a high level of erosion for its entire length decreasing slightly at its juncture with Nakomis Beach. Unfortunately, no shoreline change data is available for Nakomis Beach because the shoreline did not exist on the aerial photos during this period. The volumetric change bargraph again substantiates the shoreline change data showing massive accretion along Lagoons Beach with subsequent erosion along Linwood Beach.

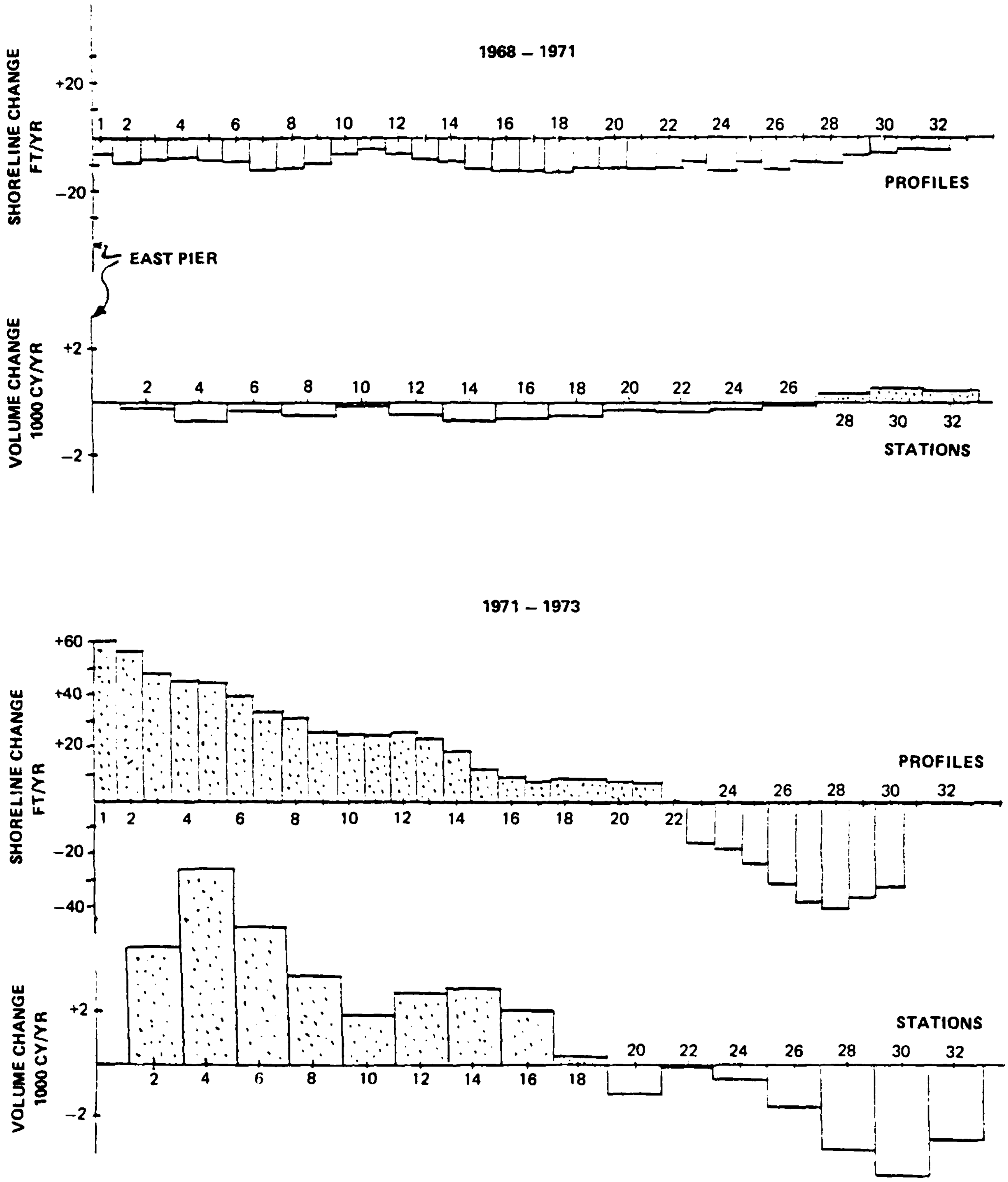


Figure 4.1.1 **SHORELINE TRENDS COMPARISON**

1974-1977

This post breakwater period comparison is shown on the lower half of Figure 4.1.2. The shoreline change bargraph shows low levels of accretion for the first 400 feet east of the east pier thence low to moderate levels of erosion along Linwood Beach with slight accretion again at the western limit of Nakomis Beach. This dramatic change in comparison to the 1973-74 period suggests that the shoreline has nearly stabilized after breakwater construction and a moderate amount of readjustment is taking place.

The volumetric change bar chart compares favorably with the shoreline change chart except for the eastern stretch of Linwood Beach from station 17 to 27. The volumetric change analysis shows small amounts of accretion in this region while the shoreline change data shows small amounts of erosion. This discreptancy may be due to accretion of material below the waterline which would happen prior to beach width growth and would not show up in the aerial photography analysis.

1977-1979

Further redistribution of shoreline sediments occurred during this period shown in Figure 4.1.3. The shoreline change rate bar chart shows continued but low level erosion adjacent to the east pier and low to moderate accretion over the length of Linwood Beach. At the western most end of Nakomis Beach slight erosion is evident. The volumetric change bar chart, however, shows moderate erosion along Lagoons Beach, slight accretion along the western 500 ft of Linwood Beach and low level erosion along the remainder of Linwood. It is possible that the time differences between the March 1977 aerial photograph and the October 1977 volumetric survey is enough to cause these trend irregularities. The fact that the water level during the October 1977 survey was about one half foot higher than at the time of the March 1977 aerial photo could explain the increased erosional activity noted in the volumetric change bar graph.

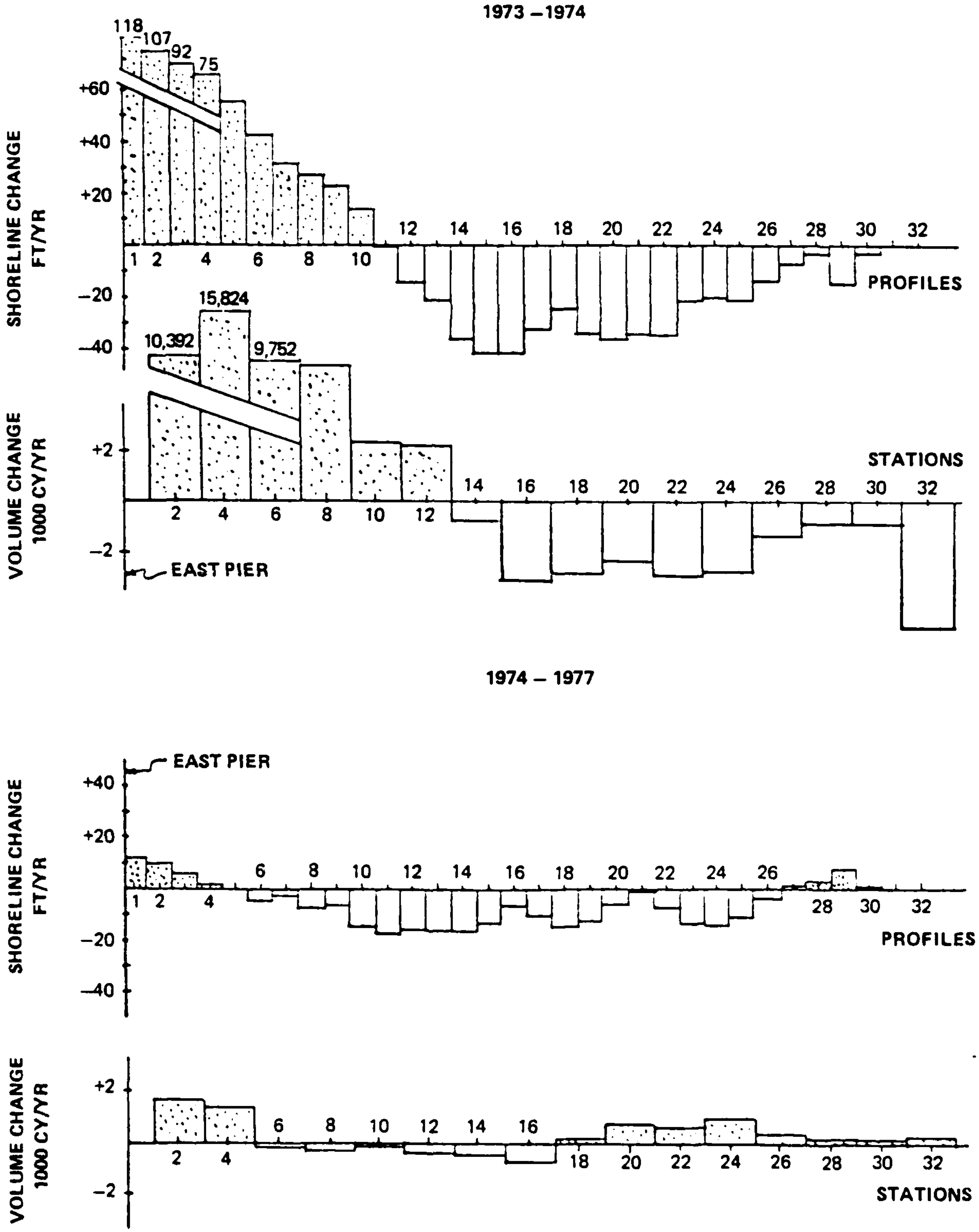


Figure 4.1.2 **SHORELINE TRENDS COMPARISON**

1979-1980

Redistribution of beach material from west to east continues during this period shown on the lower half of Figure 4.1.3. The shoreline change and volumetric change bar graphs are almost identical in trends showing moderate erosion from the east pier to station 20 thence accretion along the eastern stretches of Linwood and western stretches of Nakomis Beaches.

In general, the agreement between the volumetric and shoreline change bar charts over the six periods studied was unusually good. Shoreline areas of accretion and erosion uniformly coincided and the magnitudes and fluctuations of change as shown by the length of bars was very similar between the two data sets.

4.2 IMPACT OF THE BREAKWATER ON SHORELINE TRENDS

Immediately prior to the completion of the breakwater in December 1973, high level accretion was taking place adjacent to the east pier and all along Lagoons and the western portion of Linwood Beach. The eastern portion of Linwood Beach and Nakomis Beach were experiencing erosion. This accretion was evidently the result of abnormally high lake levels coupled with a predominant wave direction from the north east. In the 1973-74 period including breakwater completion, the level of accretion along Lagoons Beach had doubled to a maximum rate of 120 ft/yr at the expense of Linwood Beach which suffered average erosion on the order of 40 ft/yr. In this time frame, the effect of the breakwater combined with the high water and dominance of waves from the northeast had been to impound westerly moving nearshore sediment in its lee causing rapid beach growth adjacent to the east harbor pier and along Lagoons Beach.

In the 1974-1977 and the 1977-1979 time periods recovery began to take place on Linwood and Nakomis Beaches with the Lagoons Beach area fillet accreting slightly in 1974-1977 but eroding in 1977 to 1979. In the 1979-80 time period the entire stretch of Lagoons Beach is shown eroding with eastern Linwood and Nakomis Beaches recovering well. Apparently in the period 1977 to 1980

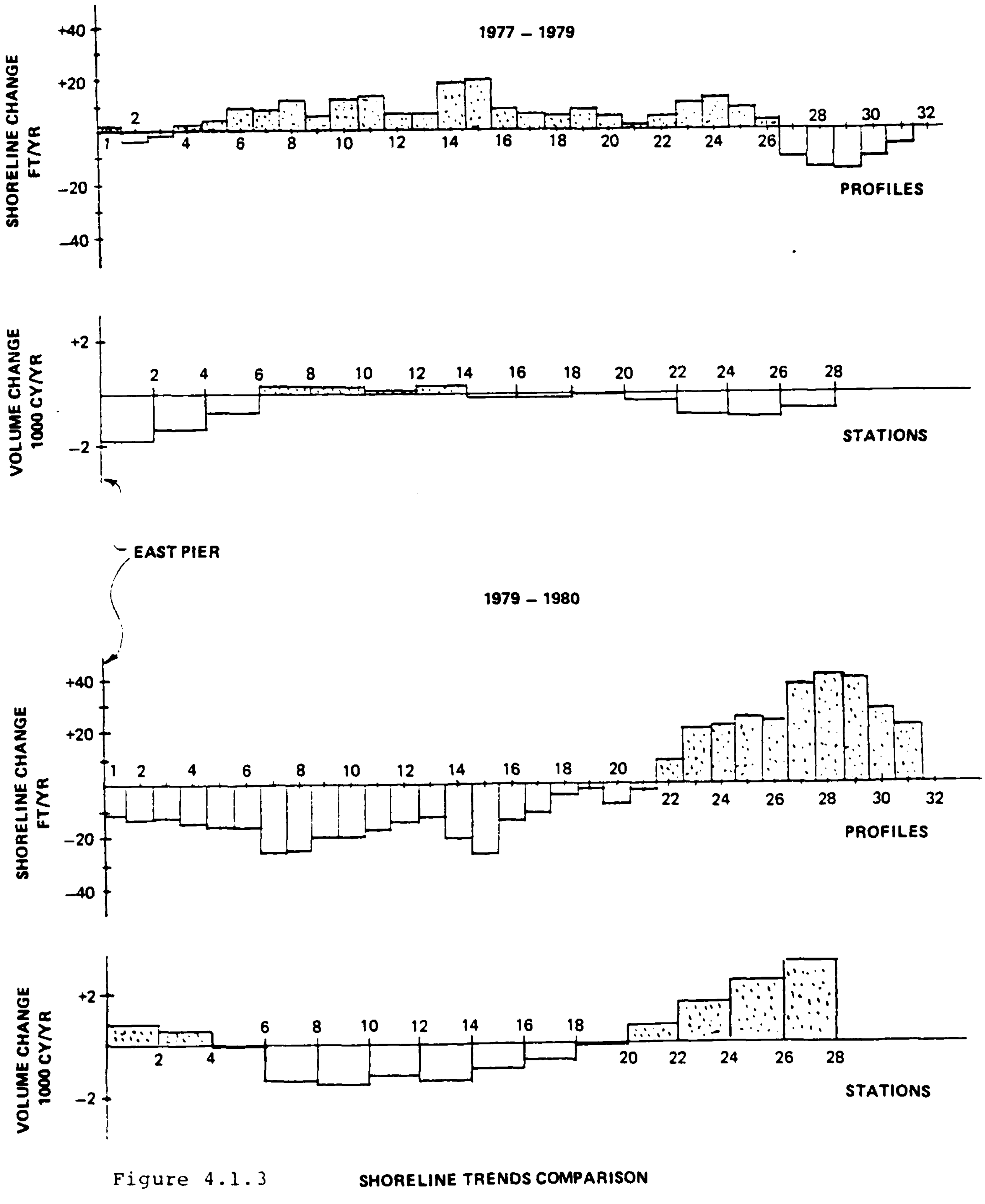


Figure 4.1.3 SHORELINE TRENDS COMPARISON

(especially 1979 to 1980) the predominant wave direction has shifted to the northwest helping to redistribute beach materials to the east. Redistribution of materials accumulated adjacent to the East Pier is affected by the presence of the breakwater in shielding this area from northwest waves.

For the period 1973-74, which represents the transition period of construction of the breakwater, the shoreline trend comparison shown in Figure 4.1.2 indicates there was shoreline accretion for a distance of about 1200 feet east of the East Pier thence shoreline recession easterly to the limits of study. For the period 1974-1977 (Figure 4.1.2) the shoreline trend comparison shows a greatly reduced rate of accretion in the 1200-foot sector and similar reduction in recession of the shoreline easterly thereof. From 1977 to 1980 the shoreline trend comparisons (Figure 4.1.3) show a trend toward smaller fluctuations of the shoreline east of the East Pier. This shoreline comparison suggests that for the period 1974-80 there has been littoral material movement into and away from the accumulated fillets immediately east of the East Pier with resultant shoreline change fluctuations within as well as to the east of this section. The trend from 1977-80 (Figure 4.1.3) further suggests that shoreline fluctuations during this period are comparable to those that prevailed over the period 1948-1973, or before the breakwater was constructed, in that shoreline accretion or erosion in a specific shore sector cannot be correlated with changes that occurred to an adjacent shore sector.

5.0 SUMMARY EVALUATION

5.1 FUTURE PREDICTION OF SHORELINE TRENDS

The aerial photographic coverage permitted an evaluation of shoreline changes for time increments ranging from one to eight years between the period 1948-1980. Between 1948 and immediately before construction was started on the breakwater (1973), a comparison of the incremental time aerial photo coverage shows both shore recession and accretion within the three shore segments (Lagoons, Linwood, and Nakomis) with no apparent relationship between the three shore segments. The incremental coverage between 1948 and 1973 does suggest that the Linwood segment experienced substantially more shore recession than the adjacent segment of Lagoons and Nakomis and this is in agreement with the longer time interval comparison, namely, the 1948 and 1973 photo set (Figure 3.7.1).

The 1973-74 photo coverage, which encompasses the transition period of breakwater construction, clearly shows shore accretion in the Lagoons segment and shore recession in the Linwood-Nakomis segment (Figure 3.4.4). However, the trend indicated in the incremental photo coverage for the 1974 to 1980 period is that of shore adjustment for the accumulated fillet in the Lagoons segment with fluctuations of recession and accretion in the Linwood-Nakomis segments similar to that shown in the incremental coverages for the 1948-1973 period. Again shore recession is dominant in the Linwood segment. As in the 1948-73 period,there is no apparent relationship of shore accretion-recession between the three segments. During the period 1977-78 shore accretion prevailed in all three segments. During 1978-79 accretion prevailed in the Lagoons and the westerly half of Linwood but recession prevailed in the easterly half of Linwood and in the Nakomis segment. Then in the period 1979-80 shore recession prevailed throughout the Lagoons-Linwood segment with accretion prevailing in the Nakomis segment.

The post-breakwater period has been relatively short -6 years.. However, for this period, the shoreline change data developed from the aerial photo coverage and the volumetric changes developed from survey data appear to be in reasonable agreement and reflect that since approximately 1977 the shoreline has fluctuated (recession and accretion) throughout the study area with resultant trend of shore recession of the Linwood segment, slight recession of the Nakomis segment, and a trend toward stability adjustment of the Lagoons segment. The **rate** shown by the 1948-80 long-range data (Figure 3.7.1) for the Lagoons Beach segment is that accretion has averaged 3 feet per year. However, this value is influenced by the significant accumulation of littoral material immediately east of the East Pier during the transition period 1973-74 (breakwater construction period) and based on the trend for this segment since about 1977 it is reasoned that in the future there will continue to be fluctuations of the shoreline with negligible net erosion or accretion in the long term.

The 1948-80 long range trend shown for the Linwood segment is that of one to two feet of recession per year and based on the trend for this segment since about 1977 it is reasoned that in the future the net change of shore position will average this amount per year. The predicted future rate of shore recession for the Nakomis segment is zero to one foot per year and is based on the value developed for the 1948-80 long range data.

5.2 SUMMARY

The results of the aerial photographic analysis show that the position of the shoreline east of Vermilion Harbor has experienced significant changes over the 32 year study period. The total alongshore length of the beach has fluctuated between 3,100 and 3,800 feet with the minimum length being measured in 1958 and 1979.

Volumetric shoreline change rate trends determined from bathymetric survey analysis were compared to the combined aerial photo data base. Very good agreement was found between the two types of data, indicating that the trends shown were a valid documentation of historical shoreline changes.

Short-term trend comparison of the pre vs post-breakwater periods indicated that the growth of the fillet adjacent to the east pier during the years immediately before and just after breakwater construction had stopped and erosion was evident in the most recent series of photographic comparisons. The eastern reaches of Linwood and the Nakomis Beaches were accreting in the 1977-1980 period indicating a possible west to east redistribution of beach material from the Lagoons segment during this period.

In summary, the aerial photo coverage and the field survey data show that for the Lagoons-Linwood-Nakomis segments the trend of the shoreline before breakwater construction was that of slight accretion in the Lagoons, one to two feet per year recession for Linwood, and zero to one foot per year recession for the Nakomis segment. During and immediately after breakwater construction there was substantial shoreline accretion in the Lagoons sector, and increased recession in the Linwood and Nakomis segments. This post-breakwater trend of increased shoreline accretion for Lagoons and increased recession for Linwood and Nakomis progressively reduced and the data for the period 1977 to 1980 indicate the fluctuations and trend of the shoreline in the three segments are comparable to that shown for the pre-breakwater period. This further indicates that the influence of the breakwater on the fluctuations and trends of the shoreline east of the East Pier have been minimal since 1977.

APPENDIX A

Shoreline Position and Change Rates
September 1980 Data Base

VERMILION SHORELINE DOC. EAST OF JETTYS

*** MEASURED SHORE LINE POSITIONS ***

PROFILE NUMBER	YEAR 1950	1958	1964	1971	1977	1979
1	451	455	394	334	644	633
2	407	399	360	288	571	550
3	385	371	334	263	437	483
4	360	356	311	248	447	439
5	357	353	300	243	409	404
6	345	353	30[illegible]	242	371	375
7	343	347	306	238	346	349
8	322	326	295	227	310	324
9	342	321	294	232	302	302
10	335	330	304	250	284	299
11	339	328	314	264	276	291
12	357	334	325	278	279	280
13	358	333	332	301	288	289
14	378	353	351	324	280	309
15	379	374	372	329	277	305
16	359	359	367	318	280	285
17	358	341	367	310	271	272
18	360	328	365	306	267	266
19	353	340	373	315	267	271
20	365	350	372	314	279	278
21	341	343	377	306	285	278
22	363	334	382	310	260	259
23	357	327	384	314	235	243
24	355	314	383	313	231	244
25	343	311	382	317	[illegible]	236
26	336	308	379	318	248	240
27	320	300	375	317	255	218
28	312	283	368	313	255	209
29	303	265	362	310	260	214
30	294	264	351	314	26[illegible]	229
31	292	267	345	320	275	246
32	291	264	347	327	276	
33	293		344	335	287	
34	303		340	346	306	
35	306		343	356	324	
36	337		345	377	345	
			352	407	380	
				433	427	

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VERMILION SHORELINE DOC. EAST OF JETTYS

*** CORRECTED SHORE LINE POSITIONS ***

PROFILE NUMBER	YEAR 1950	1958	1964	1971	1977	1979
1	441	442	376	343	638	642
2	398	388	343	297	566	558
3	377	360	318	272	493	490
4	351	345	296	257	442	446
5	348	342	284	251	404	411
6	337	343	288	250	366	382
7	336	337	291	245	341	356
8	315	317	282	234	306	330
9	335	313	282	238	296	308
10	329	321	292	257	280	304
11	332	319	301	271	272	297
12	350	325	312	285	275	286
13	351	324	319	308	284	295
14	371	343	337	331	279	315
15	371	364	357	336	273	312
16	351	349	352	326	276	292
17	349	330	351	318	266	279
18	352	317	350	314	262	273
19	345	330	359	322	263	278
20	356	340	358	322	274	284
21	334	334	364	313	281	284
22	355	325	367	318	256	265
23	346	316	368	322	230	251
24	347	303	366	321	226	251
25	334	300	365	326	228	244
26	326	296	361	326	243	249
27	310	286	355	328	249	227
28	301	269	348	323	249	219
29	292	250	341	322	254	223
30	283	249	330	325	262	239
31	281	253	324	332	268	256
32	279	250	326	338	270	
33	282		323	346	280	
34	292		320	357	299	
35	294		322	368	317	
36	325		325	388	339	
			331	419	375	
				444	421	

TETRA TECH INC.
PASADENA, CALIF.

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VERMILION SHORELINE DOC. EAST OF JETTYS

*** EROSION RATES (FT/YR) USING MEASURED SHORE LINE POSITIONS

PROF.
NO. YEAR
1950 1958 1964 1971 1977 1979

1	0.5	-10.4	-8.7	53.3	-5.0
2	-1.0	-6.7	-10.3	48.6	-9.9
3	-1.8	-6.3	-10.2	40.2	-6.7
4	-0.5	-7.7	-9.1	34.1	-3.6
5	-0.5	-9.1	-8.2	28.5	-2.3
6	1.1	-8.5	-8.8	22.1	2.1
7	0.4	-7.1	-9.8	18.6	1.6
8	0.5	-5.4	-9.8	14.3	6.5
9	-2.7	-4.6	-8.9	12.0	0.3
10	-0.8	-4.4	-7.7	5.8	6.9
11	-1.5	-2.4	-7.1	2.0	7.2
12	-3.0	-1.4	-6.9	0.2	0.5
13	-3.2	-0.2	-4.5	-2.1	0.5
14	-3.3	-0.3	-3.8	-7.1	12.4
15	-0.7	-0.3	-6.2	-8.8	13.2
16	0.1	1.3	-7.0	-6.6	2.4
17	-2.1	4.4	-8.2	-6.7	0.5
18	-4.2	6.4	-8.5	-6.7	-0.5
19	-1.7	5.7	-8.4	-8.1	1.8
20	-2.0	3.9	-8.3	-6.1	-0.2
21	0.3	5.8	-10.2	-3.6	-3.1
22	-3.6	8.1	-10.3	-8.6	-0.7
23	-3.9	9.8	-10.1	-13.6	4.1
24	-5.3	11.7	-10.1	-14.1	6.0
25	-4.1	12.0	-9.3	-14.4	1.4
26	-3.6	12.1	-8.7	-12.0	-2.5
27	-2.7	12.9	-8.3	-10.7	-17.3
28	-3.7	14.5	-7.9	-9.8	-21.8
29	-5.0	16.6	-7.4	-8.6	-22.2
30	-3.9	15.0	-5.3	-7.7	-18.7
31	-3.2	13.4	-3.6	-7.8	-13.6
32	-3.4	14.2	-2.8	-8.8	
33		3.8	-1.3	-8.4	
34		2.7	0.8	-6.9	
35		2.8	1.9	-5.7	
36		0.7	4.5	-5.4	
37			8.0	-4.8	
				-0.9	

[illegible] ELINE DOC. [illegible]

[illegible] EROSION RATES [illegible] USING MEASURED [illegible]

PROF. NO. — YEAR: 1950, 1958, 1964, 1971, 1977, 1979

PROF. NO.					
1	5.2	-11.4	-4.7	50.7	1.6
2	-1.3	-7.6	-6.6	46.1	-1.8
3	-2.1	-7.1	-6.7	38.0	-1.0
4	-0.8	-8.5	-5.6	21.9	1.9
5	-0.8	-9.9	-4.8	26.2	1.4
6	0.8	-3.3	-5.5	20.0	7.5
7	0.2	-7.8	-6.6	16.5	6.3
8	0.3	-6.1	-6.9	12.4	11.2
9	-1.9	-5.2	-6.3	10.3	4.6
10	-1.0	-5.0	-5.0	4.0	11.4
11	-1.8	-2.1	-4.2	0.1	12.0
12	-3.2	-2.1	-4.0	-1.7	5.3
13	-3.5	-0.9	-1.6	-4.0	5.2
14	-3.5	-1.1	-0.8	-3.1	17.4
15	-1.0	-1.1	-3.0	-10.9	13.4
16	-0.2	0.5	-3.7	-6.7	[illegible]
17	-2.4	3.6	-4.8	-9.0	[illegible]
18	-4.5	5.6	-5.2	-6.9	4.9
19	-1.0	5.0	-5.3	-10.2	7.0
20	-2.3	3.1	-5.3	-6.1	4.6
21	0.0	5.1	-7.3	-5.5	[illegible]
22	-3.9	7.3	-7.1	-10.7	4.5
23	-4.1	9.0	-6.6	-15.3	[illegible]
24	-5.6	10.9	-6.5	-16.4	13.9
25	-4.5	11.1	-5.5	-16.9	[illegible]
26	-3.9	11.1	-4.7	-14.6	[illegible]
27	-3.1	11.8	-3.9	-11.6	-10.3
28	-4.1	13.4	-3.5	-12.[illegible]	-14.4
29	-5.4	15.5	-2.8	-11.6	-14.6
30	-4.3	13.9	-0.7	-10.3	-11.1
31	-2.6	1[illegible].3	1.0	-10.9	[illegible]
32	-3.8	13.1	1.8	-11.8	
33		3.1	3.3	-11.4	
34		2.0	5.4	-9.9	
35		3.1	6.5	-3.7	
36		-0.0	3.1	-6.5	
37			12.6	-7.8	
				-4.0	

APPENDIX B

Shoreline Position and Change Rates
May 1981 Data Base

TETRA TECH INC.
PASADENA, CALIF.

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FILE NO ______
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VERMILION BL STUDY 2

*** MEASURED SHORE LINE POSITIONS ***

PROFILE NUMBER	YEAR 1980	1978	1974	1973	1968	1948
1	606	626	576	428	361	431
2	522	529	510	377	324	392
3	455	471	451	337	294	367
4	408	425	410	317	279	339
5	371	391	378	309	275	315
6	343	359	351	300	276	307
7	304	325	324	285	280	293
8	281	304	304	271	268	282
9	268	292	296	268	266	279
10	263	284	298	283	274	284
11	258	275	295	296	334	323
12	252	272	294	312	302	333
13	263	275	305	331	330	348
14	271	286	299	344	356	394
15	259	279	283	335	359	388
16	256	271	268	319	361	378
17	248	266	265	305	353	356
18	251	267	274	304	350	339
19	259	268	270	313	353	348
20	253	270	266	312	353	346
21	266	273	262	305	346	341
22	260	264	252	295	350	333
23	263	251	237	266	349	320
24	264	245	235	260	357	302
25	260	244	228	254	352	306
26	262	239	222	238	363	307
27	259	234	214	223	355	301
28	254	234	209	213	348	289
29	257	237	199	217	340	281
30	255	240	225	228	342	284
31	264	250			343	304
32	265				351	302
33	261				360	308
34	262				367	326
35	270				382	300
					395	
					[illegible]	
					410	

TETRA TECH INC. PASADENA, CALIF	SUBJECT ______	PROJECT ______
		FILE NO ______
	COMPUTED ______ CHECKED ______	DATE ______ PAGE ____ OF ____ PAGES

[illegible]MILICH SL STUDY 2

+++ CORRECTED SHORE LINE POSITIONS +++

PROFILE NUMBER	YEAR 1980	1978	1974	1972	1968	1948
1	626	644	607	459	362	433
2	540	546	539	405	325	393
3	472	486	478	363	295	368
4	425	440	437	343	280	340
5	388	406	404	336	276	316
6	359	374	377	325	278	309
7	319	339	348	309	261	294
8	295	317	326	293	269	283
9	280	303	316	288	267	280
10	276	296	319	303	275	285
11	272	288	317	318	285	324
12	266	285	316	334	303	334
13	277	288	327	352	321	349
14	266	299	322	367	357	395
15	274	291	307	359	370	389
16	271	286	293	344	362	373
17	264	282	291	331	354	357
18	257	282	299	329	351	340
19	275	282	294	337	354	349
20	271	284	290	335	354	347
21	280	286	294	327	347	342
22	276	278	276	313	352	324
23	280	266	266	292	350	321
24	281	262	263	288	354	303
25	279	261	256	282	354	307
26	282	257	253	269	364	319
27	280	254	247	256	357	302
28	276	254	243	247	350	290
29	279	258	234	279	342	283
30	278	261	260		343	286
31	286	271			3	305
32	287				32	304
33	284				361	309
34	294				368	328
35	293				384	332
36						

TETRA TECH INC. PASADENA, CALIF	SUBJECT	PROJECT
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VERMILION SE RUN 2

*** EROSION RATES (FT/YR) USING MEASURED SHORE LINE POSITION

PROF.
NO.   YEAR
1980   1978   1974   1973   1968   1948

1	-8.3	13.1	121.6	13.4	-2.5
2	-2.9	5.0	109.9	10.4	-3.4
3	-6.5	5.1	94.4	8.5	-2.6
4	-7.0	3.8	77.0	7.4	-3.0
5	-8.1	3.4	56.5	6.8	-2.0
6	-6.9	2.1	42.1	4.7	-1.6
7	-8.8	0.3	31.7	1.0	-0.7
8	-9.5	-0.2	27.7	0.4	-0.7
9	-10.1	-1.1	22.7	0.5	-0.7
10	-8.7	-2.7	12.4	1.6	-0.5
11	-7.1	-5.2	-0.7	2.4	-1.9
12	-6.6	-5.8	-14.4	1.9	-1.5
13	-4.8	-8.0	-21.3	0.3	-0.9
14	-6.2	-3.5	-36.7	-2.4	-1.9
15	-8.3	-1.0	-42.9	-6.7	-1.0
16	-6.5	0.9	-42.0	-8.4	-0.8
17	-7.7	0.3	-32.7	-9.6	-0.1
18	-6.5	-1.7	-24.8	-9.3	0.6
19	-3.4	-0.6	-35.0	-6.0	0.2
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
21	-3.1	3.0	-35.0	-9.2	0.2
22	-1.5	3.3	-35.5	-11.1	0.9
23	5.2	3.0	-21.8	-16.5	1.5
24	7.7	2.7	-20.9	-19.3	2.3
25	6.8	4.4	-21.5	-19.7	2.3
26	9.8	4.5	-13.7	-24.8	2.8
27	10.4	5.3	-7.5	-26.3	2.7
28	8.5	6.7	-3.8	-26.9	3.0
29	8.5	3.8	-14.9	-24.4	2.9
30	6.5	3.9	-2.1	-22.6	2.9
31	5.8		-53		2.0
32	0.9		-6.9		2.4
33	1.2		-8.0		2.6
34	-0.4		-8.5		2.0
35	0.2		-11.2		2.6

TETRA TECH INC.
PASADENA, CALIF.

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VERMILION SL STUDY 2

** EROSION RATES (FT/YR) USING MEASURED, CORRECTED SHORE LI

PROF.
NO.
YEAR
1982 1978 1974 1973 1968 1948

1	-7.8	9.8	121.6	19.2	-3.5
2	-2.4	1.9	109.9	15.8	-3.4
3	-6.0	2.3	94.4	13.6	-3.6
4	-6.5	0.9	77.0	12.5	-3.0
5	-7.6	0.5	56.5	11.8	-2.0
6	-6.4	-0.6	42.1	9.5	-1.6
7	-8.3	-2.3	31.7	5.6	-0.7
8	-9.1	-2.5	27.7	4.6	-0.7
9	-9.7	-3.2	22.7	4.3	-0.7
10	-8.3	-5.9	12.4	5.6	-0.5
11	-6.7	-7.6	-0.7	6.5	-1.9
12	-8.1	-8.2	-14.4	6.1	-1.5
13	-4.4	-10.4	-21.3	4.4	-0.9
14	-5.7	-6.0	-36.7	1.9	-1.9
15	-7.9	-3.6	-42.9	-2.2	-1.0
16	-6.0	-1.8	-42.0	-3.6	-0.8
17	-7.2	-2.6	-32.7	-4.6	-0.1
18	-6.0	-4.5	-24.8	-4.5	0.6
19	-3.0	-3.2	-35.3	-3.4	0.2
20	-4.6	-1.4	-37.7	-3.6	0.3
21	-2.7	0.7	-35.3	-4.0	0.2
22	-1.1	0.7	-35.5	-6.5	0.9
23	5.7	0.1	-21.8	-11.5	1.5
24	8.2	-0.2	-20.9	-14.0	2.8
25	7.3	1.3	-21.5	-14.2	2.3
26	10.4	1.2	-13.7	-18.9	2.8
27	11.1	1.7	-7.5	-20.0	2.7
28	9.2	3.0	-3.8	-20.4	3.0
29	9.2	6.1	-14.9	-17.7	2.9
30	7.1	0.1	-2.1	-15.9	2.9
31	6.4		-7.4		2.0
32	1.6	-5.2			.4
33	1.9				5
	0.2	-6.2			
	.4	-6.8			
		-7.3			

APPENDIX C

Shoreline Change Rates
Combined Data Base

VERMILION SHORELINE CHANGE RATES EAST OF JETTIES

Time Frame: April 1968 to May 1971 = 3.083 yrs.

PROFILE NUMBER	CORRECTED SHORELINE DISTANCE FROM BASELINE		CHANGE RATE FT/YR.
	1968	1971	
1	362	343	- 6.2
2	325	297	- 9.1
3	295	272	- 7.5
4	280	257	- 7.5
5	276	251	- 8.1
6	278	250	- 9.1
7	281	245	- 11.7
8	269	234	- 11.4
9	267	238	- 9.4
10	275	257	- 5.8
11	285	271	- 4.5
12	303	285	- 5.8
13	331	308	- 7.5
14	357	331	- 8.4
15	370	336	- 11.0
16	362	326	- 11.7
17	354	318	- 11.7
18	351	314	- 12.0
19	354	322	- 10.4
20	354	322	- 10.4
21	347	313	- 11.0
22	352	318	- 11.0
23	350	322	- 9.1
24	359	321	- 12.3
25	354	326	- 9.1
26	364	328	- 11.7
27	357	328	- 9.4
28	350	323	- 8.8
29	342	322	- 6.5
30	343	325	- 5.8
31	345	332	- 4.2
32	352	338	- 4.5

VERMILION SHORELINE CHANGE RATES EAST OF JETTIES

Time Frame: May 1971 to April 1973 = 1.9167 yrs.

PROFILE NUMBER	CORRECTED SHORELINE DISTANCE FROM BASELINE		CHANGE RATE FT/YR.
	1971	1973	
1	343	459	+ 60.5
2	297	405	+ 56.3
3	272	363	+ 47.5
4	257	343	+ 44.9
5	251	336	+ 44.4
6	250	325	+ 39.1
7	245	309	+ 33.4
8	234	293	+ 30.1
9	238	288	+ 26.1
10	257	303	+ 24.0
11	271	318	+ 24.5
12	285	334	+ 25.6
13	308	353	+ 23.5
14	331	367	+ 18.8
15	336	359	+ 12.0
16	326	344	+ 9.4
17	318	331	+ 6.8
18	314	329	+ 7.8
19	322	337	+ 7.8
20	322	335	+ 6.8
21	313	327	+ 7.3
22	318	319	+ 0.5
23	322	292	- 15.7
24	321	288	- 17.2
25	326	282	- 22.9
26	328	269	- 30.8
27	328	256	- 37.6
28	323	247	- 39.7
29	322	253	- 36.0
30	325	263	- 32.3
31	332		
32	338		

VERMILION SHORELINE CHANGE RATES EAST OF JETTIES

Time Frame: April 1973 to July 1974 = 1.25 yrs.

PROFILE NUMBER	CORRECTED SHORELINE DISTANCE FROM BASELINE 1973	1974	CHANGE RATE FT/YR.
1	459	607	+ 118.4
2	405	539	+ 107.2
3	363	478	+ 92.0
4	343	437	+ 75.2
5	336	404	+ 54.4
6	325	377	+ 41.6
7	309	348	+ 31.2
8	293	326	+ 26.4
9	288	316	+ 22.4
10	303	319	+ 12.8
11	318	317	- 0.8
12	334	316	- 14.4
13	353	327	- 20.8
14	367	322	- 36.0
15	359	307	- 41.6
16	344	293	- 40.8
17	331	291	- 32.0
18	329	299	- 24.0
19	337	294	- 34.4
20	335	290	- 36.0
21	327	284	- 34.4
22	319	276	- 34.4
23	292	266	- 20.8
24	288	263	- 20.0
25	282	256	- 20.8
26	269	253	- 12.8
27	256	247	- 7.2
28	247	243	- 3.2
29	253	234	- 15.2
30	263	260	- 2.4
31			
32			

VERMILION SHORELINE CHANGE RATES EAST OF JETTIES

Time Frame: July 1974 to March 1977 = 2.67 yrs.

PROFILE NUMBER	CORRECTED SHORELINE DISTANCE FROM BASELINE		CHANGE RATE FT/YR.
	1974	1977	
1	607	638	+ 11.6
2	539	566	+ 10.1
3	478	493	+ 5.6
4	437	442	+ 1.9
5	404	404	0.0
6	377	366	- 4.1
7	348	341	- 2.6
8	326	306	- 7.5
9	316	298	- 6.7
10	319	280	- 14.6
11	317	272	- 16.9
12	316	275	- 15.4
13	327	284	- 16.1
14	322	279	- 16.1
15	307	273	- 12.7
16	293	276	- 6.4
17	291	266	- 9.4
18	299	262	- 13.9
19	294	263	- 11.6
20	290	274	- 6.0
21	284	281	- 1.1
22	276	256	- 7.5
23	266	230	- 13.5
24	263	226	- 13.9
25	256	228	- 10.5
26	253	243	- 3.7
27	247	249	+ 0.8
28	243	249	+ 2.2
29	234	254	+ 7.5
30	260	262	+ 0.8
31		268	
32		270	

VERMILION SHORELINE CHANGE RATES EAST OF JETTIES

Time Frame: March 1977 to April 1979 = 2.083 yrs.

PROFILE NUMBER	CORRECTED SHORELINE DISTANCE FROM BASELINE 1977	1979	CHANGE RATE FT/YR.
1	638	642	+ 1.9
2	566	558	- 3.8
3	493	490	- 1.4
4	442	446	+ 1.9
5	404	411	+ 3.4
6	366	382	+ 7.7
7	341	356	+ 7.2
8	306	330	+11.5
9	298	308	+ 4.8
10	280	304	+11.5
11	272	297	+12.0
12	275	286	+ 5.3
13	284	295	+ 5.3
14	279	315	+17.3
15	273	312	+18.7
16	276	292	+ 7.7
17	266	279	+ 6.2
18	262	273	+ 5.3
19	263	278	+ 7.2
20	274	284	+ 4.8
21	281	284	+ 1.4
22	256	265	+ 4.3
23	230	251	+10.1
24	226	251	+12.0
25	228	244	+ 7.7
26	243	249	+ 2.9
27	249	227	-10.6
28	249	219	-14.4
29	254	223	-14.9
30	262	239	-11.0
31	268	256	- 5.8
32	270		

VERMILION SHORELINE CHANGE RATES EAST OF JETTIES

Time Frame: April 1979 to Sept. 1980 = 1.417 yrs.

PROFILE NUMBER	CORRECTED SHORELINE DISTANCE FROM BASELINE 1979	1980	CHANGE RATE FT/YR.
1	642	626	- 11.3
2	558	540	- 12.7
3	490	472	- 12.7
4	446	425	- 14.8
5	411	388	- 16.2
6	382	359	- 16.2
7	356	319	- 26.1
8	330	295	- 24.7
9	308	280	- 19.8
10	304	276	- 19.8
11	297	272	- 17.6
12	286	266	- 14.1
13	295	277	- 12.7
14	315	286	- 20.5
15	312	274	- 26.8
16	292	272	- 14.1
17	279	264	- 10.6
18	273	267	- 4.2
19	278	275	- 2.1
20	284	273	- 7.8
21	284	280	- 2.8
22	265	276	+ 7.8
23	251	280	+ 20.5
24	251	281	+ 21.2
25	244	279	+ 24.7
26	249	282	+ 23.3
27	227	280	+ 37.4
28	219	276	+ 40.2
29	223	279	+ 39.5
30	239	278	+ 27.5
31	256	286	+ 21.2
32			

APPENDIX D

STANLEY, INC. AND CORPS OF ENGINEERS VOLUMETRIC CHANGE DATA

VOLUMETRIC DATA - Pre Breakwater Period

Station Interval	Net Change in Volume (Cubic Yards) Stanley Data April 68 - April 71	Net Change in Volume (Cubic Yards) Stanley Data April 71 - April 73	Total Volume Change 68-73	Volumetric Change Rate Cubic yds./yr.
0 - 2 +00	0	+ 17500	+ 17500	+ 3500
2 - 4	- 2690	+ 23880	+ 21190	+ 4238
4 - 6	- 2930	+ 25530	+ 22600	+ 4520
6 - 8	- 2440	+ 17220	+ 14780	+ 2956
Lagoons	- 8060	+ 84130	+ 76070	+ 15214
8 - 10	- 1850	+ 10570	+ 8720	+ 1744
10 - 12	- 1520	+ 9380	+ 7860	+ 1572
12 - 14	- 3150	+ 11180	+ 8030	+ 1606
14 - 16	- 3950	+ 9370	+ 5420	+ 1084
16 - 18	- 3810	+ 4220	+ 410	+ 82
18 - 20	- 2670	- 1630	- 4300	- 860
20 - 22	- 1870	- 2360	- 4230	- 846
22 - 24	- 1820	- 1200	- 3020	- 604
24 - 26	- 1060	- 4750	- 5810	- 1162
Linwood	-21700	+ 34780	+ 13080	+ 2616
26 - 28	+ 220	- 10140	- 9920	- 1984
28 - 30	+ 1770	- 15010	- 13240	- 2648
30 - 32	+ 3000	- 14450	- 11450	- 2290
32 - 34	+ 4230	- 10000	- 5770	- 1154
34 - 36	+ 5230	- 9890	- 4660	- 932
36 - 38	+ 4670	- 10890	- 6220	- 1244
38 - 40	+ 5220	- 8220	- 3000	- 600
Nakomis	+24340	- 78600	- 54260	- 10852
Net Overall	- 5420	+ 40310	+ 34890	+ 6978

VOLUMETRIC DATA - Transition Period

Station Interval	Volume Change April 73 - July 74	Volumetric Change Rate Cubic Yards/Year
0 - 2 +00	+ 28760	+ 23008
2 - 4	+ 32770	+ 26216
4 - 6	+ 31970	+ 25576
6 - 8	+ 18820	+ 15056
Lagoons	+112320	+ 89856
8 - 10	+ 9590	+ 7672
10 - 12	+ 5710	+ 4568
12 - 14	+ 1630	+ 1304
14 - 16	- 4920	- 3936
16 - 18	- 7360	- 5888
18 - 20	- 6520	- 5216
20 - 22	- 6700	- 5360
22 - 24	- 7240	- 5792
24 - 26	- 5170	- 4136
Linwood	- 20980	- 16784
26 - 28	- 2670	- 2136
28 - 30	- 2000	- 1600
30 - 32	- 7000	- 5600
32 - 34	- 12340	- 9872
34 - 36	- 9900	- 7920
36 - 38	- 8890	- 7112
38 - 40	- 12000	- 9600
Nakomis	- 54800	- 43840
Net Overall	+ 36540	+ 29232

VOLUMETRIC DATA - Post Breakwater Period

Station Interval	Net Change in Volume in Cubic Yards: Stanley Data July 74 - Oct. 77	COE Data Oct. 77 - June 79	COE Data June 79 - Aug. 80	Total Volume Post Breakwater Period 74-80	Volumetric Change Cubic Yards per yr.
0 - 2 +00	+ 14600	- 2896	+ 842	+ 12590	+ 2070
2 - 4	+ 10020	- 2283	+ 687	+ 8419	+ 1384
4 - 6	+ 4050	- 1145	- 34	+ 2871	+ 472
6 - 8	- 1920	+ 633	-1647	- 2934	- 482
Lagoons	+ 26750	- 5696	- 108	+ 20946	+ 3443
8 - 10	- 1710	+ 539	- 1792	- 2963	- 487
10 - 12	- 1670	+ 172	- 1388	- 2686	- 474
12 - 14	- 2620	+ 404	- 1660	- 3876	- 637
14 - 16	- 3710	- 369	- 1156	- 5235	- 860
16 - 18	- 1740	- 334	- 690	- 2764	- 454
18 - 20	+ 2970	- 104	- 62	+ 2804	+ 461
20 - 22	+ 4880	- 518	+ 738	+ 5100	+ 838
22 - 24	+ 5630	- 1444	+ 1806	+ 5992	+ 985
24 - 26	+ 44[illegible]	- 1643	+ 2760	+ 5587	+ 918
Linwood	+ 6500	- 3297	- 1444	+ 1759	+ 289
26 - 28	+ 1800	- 1076	+ 3605	+ 4329	+ 712
28 - 30	+ 1120				
30 - 32	+ 1550				
32 - 34	+ 1550				
34 - 36	+ 880				
36 - 38	+ 440				
38 - 40	+ 440				
Nakomis	+ 7780	Insufficient Data	Insufficient Data		
Net Overall	+ 41030	- 8993*	+ 1552*		

* Lagoons & Linwood Only

NEARSHORE VOLUME CHANGE (Cubic Yards)

PERIOD	LAGOONS BEACH	LINWOOD BEACH	NAKOMIS BEACH	TOTAL CHANGE
1968 - 1973	+76,070	+13,080	-54,260	+34,890
1973 - 1974	+112,320	-20,980	-54,800	+36,540
1974 - 1980	+20,946	+ 1,759	NO DATA	INSUFFICIENT DATA

BEACH AREA CHANGE (ACRES)

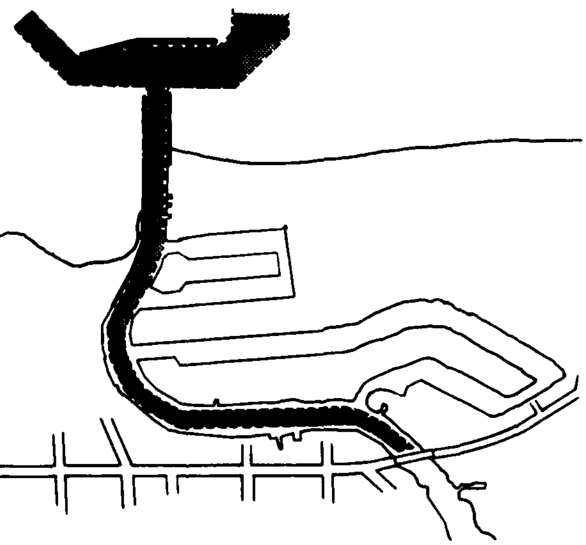
1968 - 1973	+1.20	-0.92	-0.42	-0.14
1973 - 1974	+1.84	-1.21	-0.05	+0.58
1974 - 1980	-0.23	-0.58	+0.20	-0.61

VERMILION HARBOR, OHIO

DETAILED PROJECT REPORT ON SECTION 111

SHORE EROSION STUDY

STAGE 3 DOCUMENTATION



APPENDIX B

IMPACT OF BREAKWATER ON SHORELINE PROCESSES WEST OF HARBOR

U.S. ARMY CORPS OF ENGINEERS
BUFFALO DISTRICT
1776 NIAGARA STREET
BUFFALO, NEW YORK 14207

September 1982

TC 3319

JULY 1980

FINAL REPORT

THE IMPACT OF FEDERAL NAVIGATION STRUCTURES ON SHORELINE PROCESSES SECTION 111 STUDY VERMILION HARBOR, OHIO

PREPARED FOR

UNITED STATES ARMY
CORPS OF ENGINEERS
BUFFALO DISTRICT

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1.0 GENERAL

1.1 INTRODUCTION

The Federal Government initially authorized the construction of harbor improvements at Vermilion, Ohio, in 1836. The purpose of the first harbor structures was to transform the harbor from a shallow, limited-use facility to a major port on Lake Erie devoted to the promotion of regional commerce and trade.

With limited development as a primary lake port, the main focus of the harbor users became the pursuit of recreational boating and commercial fishing. The most recent harbor improvement was completed in 1973 and consists of an 864-foot long detached breakwater located 300 feet north of the harbor entrance piers. In addition, the entrance channels to the harbor were widened and deepened at that time. Figure 1.1.1 A, B and C presents Vermilion Harbor as it appears at three periods -- in 1837, 1876, and at the present time.

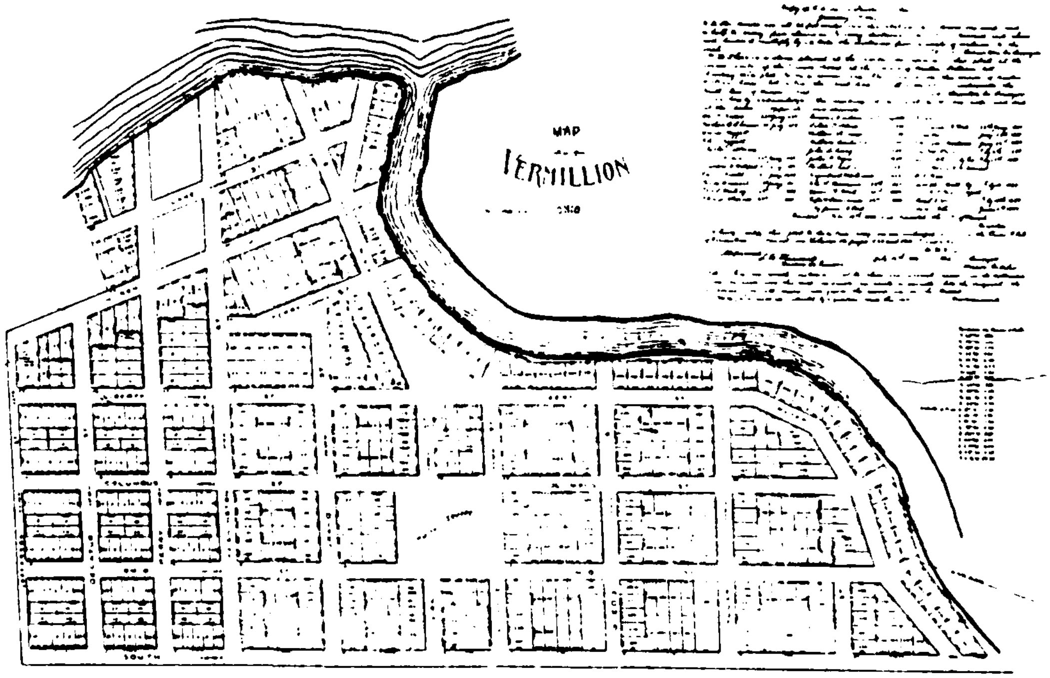


FIGURE 1.1.1. A
Original Village of Vermilion - 1837

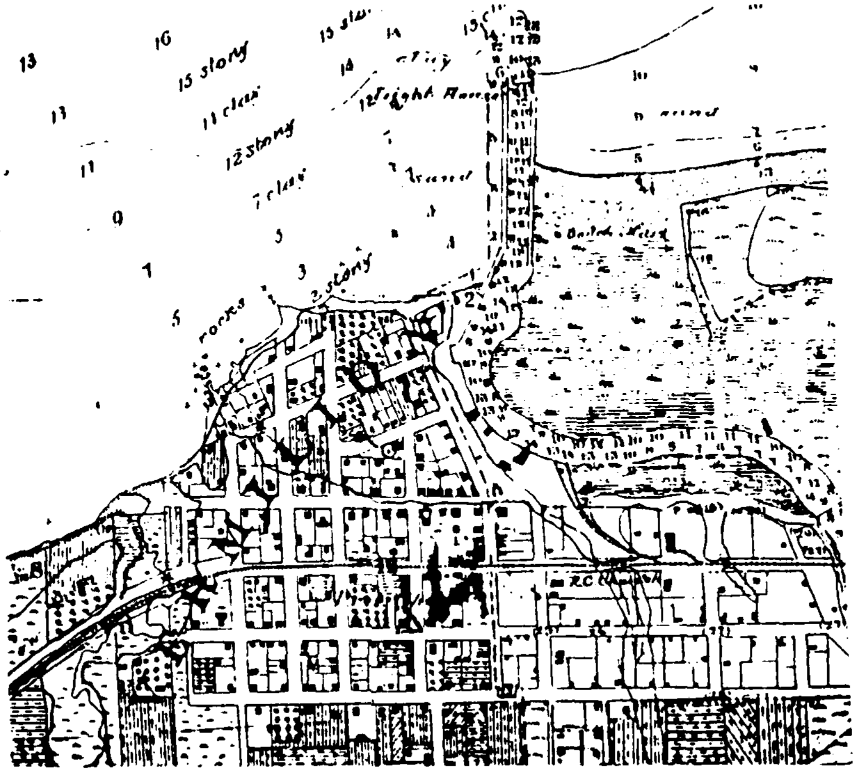


FIGURE I.1.1 B VERMILION HARBOR, 1876

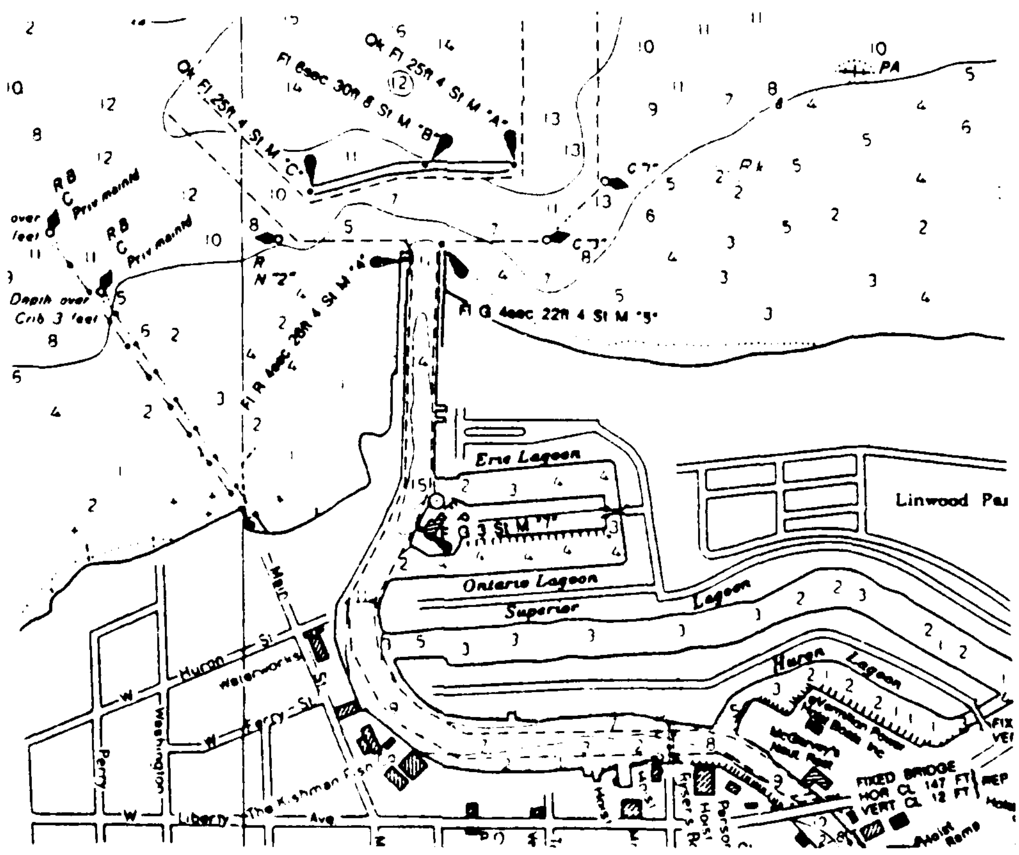


FIGURE I.1.1 C VERMILION HARBOR, 1979

Following the completion of the breakwater construction, local citizens expressed the belief that the detached breakwater altered the shoreline east of the east pier significantly and through the Ohio Department of Natural Resources, requested the Corps of Engineers Buffalo District to investigate the problem under the authority of Section 111 of Public Law 90-483. The Buffalo District completed a Reconnaissance Study Report (Stage 1 of the three-stage Section 111 investigation procedure) in January 1976. The findings and recommendations of the Reconnaissance Study Report indicated that a detailed study should be made (Stage 2 of the Section 111 procedure) to quantify any damages and investigate alternatives that would solve the problem. This was performed and presented in the Stage 2 Detailed Project Report (DPR), completed in May 1978, in which the following recommendations were made:

- Stage 3 of the Section 111 Detailed Project Report be der-taken. The alternatives recommended for final desigr r mitigation of erosion at Linwood Beach are Alternativ (sand transport from east fillet at east pier to Linw Beach) and Alternative 4 (nourishing Linwood Beach wi sand from external source). However, Alternative 4 would be implemented only if agreement cannot be reached with residents of the Vermilion Lagoon area to implement Alternative 2.
- An experimental demonstration of the Eductor-type pump system or other similar systems, as suggested in Alternative 2, be undertaken in Spring 1979 at Linwood Beach.
- The need for mitigation to the west (downdrift) be investigated in Stage 3 of this Detailed Project Report.

Although the work presented herein is being performed during Stage 3 of the Vermilion Section 111 Detailed Project Report, this investigation which focuses on determining the extent of shoreline changes, erosion, and damages, if any to the west of the Vermilion Harbor structures) is a Stage 2 study. Based on the results of this Stage 2 work, further detailed studies may be needed to complete the Detailed Project Report. If additional studies are required, they will be carried out as part of the overall Stage 3 study

which will combine the erosion problem to the east of the harbor structures (Stanley Consultants,1978,Stage 2 Study) with those to the west (reported herein) and presented in the Vermilion Harbor Section 111 Detailed Project Report.

The purpose of this investigation is summarized as follows:

- o To determine the extent of shoreline erosion and damages, if any, to the west of the Vermilion Harbor entrance structures and to distinguish between erosion caused by the Federal navigation works and those caused by natural processes.
- o To prepare preliminary designs and cost estimates for a range of alternative plans to mitigate damages attributable to the Federal navigation works.
- o Based on an ecomomic analysis of each alternative, and other appropriate factors, determine if mitigation of shoreline damage is justified and recommend a specific plan.

1.2 PURPOSE OF THE STUDY

In examining the extent of shore damage and erosion and/or accretion west of Vermilion Harbor, existing data and information were used. Data sources included the U.S. Army Corps of Engineers, Buffalo District Office; the U.S. Department of Commerce, U.S. Lake Survey; the State of Ohio,Department of Natural Resources; the City of Vermilion, and private individuals. The data were analyzed to perform the following specific tasks:

1) Evaluate the littoral processes pertinent to the study area,
2) Establish historical and present-day beach and bluff recession rates,
3) Determine the resultant effects to adjacent shores attributable to the existing navigation works,

4) Estimate the shore and bluff position if no harbor structures had ever been constructed,
5) Evaluate the need for mitigation of shoreline damage caused on the west side of Vermilion Harbor by the navigation structures,
6) If erosion mitigation is deemed appropriate, specify from the various alternatives, the recommended plan of action.

1.3 LOCATION AND DESCRIPTION OF FEDERAL PROJECT

Vermilion Harbor, located at the mouth of the Vermilion River in Erie County, Ohio, is about 37 miles (by water) west of Cleveland, Ohio, as shown in Figure 1.3.1. Vermilion Harbor is comprised of east and west approach channels, the lower 3,600 feet of the Vermilion River, and four artificial lagoons. A detached breakwater built in 1973 by the Federal government.shelters the approach cnannels during moderately fresh wind and wave conditions and reduces wave and surge action in the harbor. The lagoons, constructed on the east side of the river by private interests, have depths averaging about 4 feet below the Lake Eric Low Water Datum elevation of 568.6 feet on the International Great Lakes Datum of 1955.

Until the Federal government constructed two jetties at the mouth of the Vermilion river in 1836, less than two feet of water existed over the bar at the Vermilion River mouth. The original jetties extended from each side of the river mouth lakeward to a depth of 10 feet. The distance between these parallel piers is 125 feet. The piers were composed of stone-filled timber cribs, each about 16 feet wide and 30 feet long with the top height of the cribs about five feet above Low Water Datum.

The Rivers and Harbors Act of 1875 authorized an increase in the Vermilion Harbor cnannel depth to 12 feet, extending from the 12-foot lake contour upstream for a distance of about 1,335 feet from the outer end of the entrance piers. The extensions increased the length of the east jetty

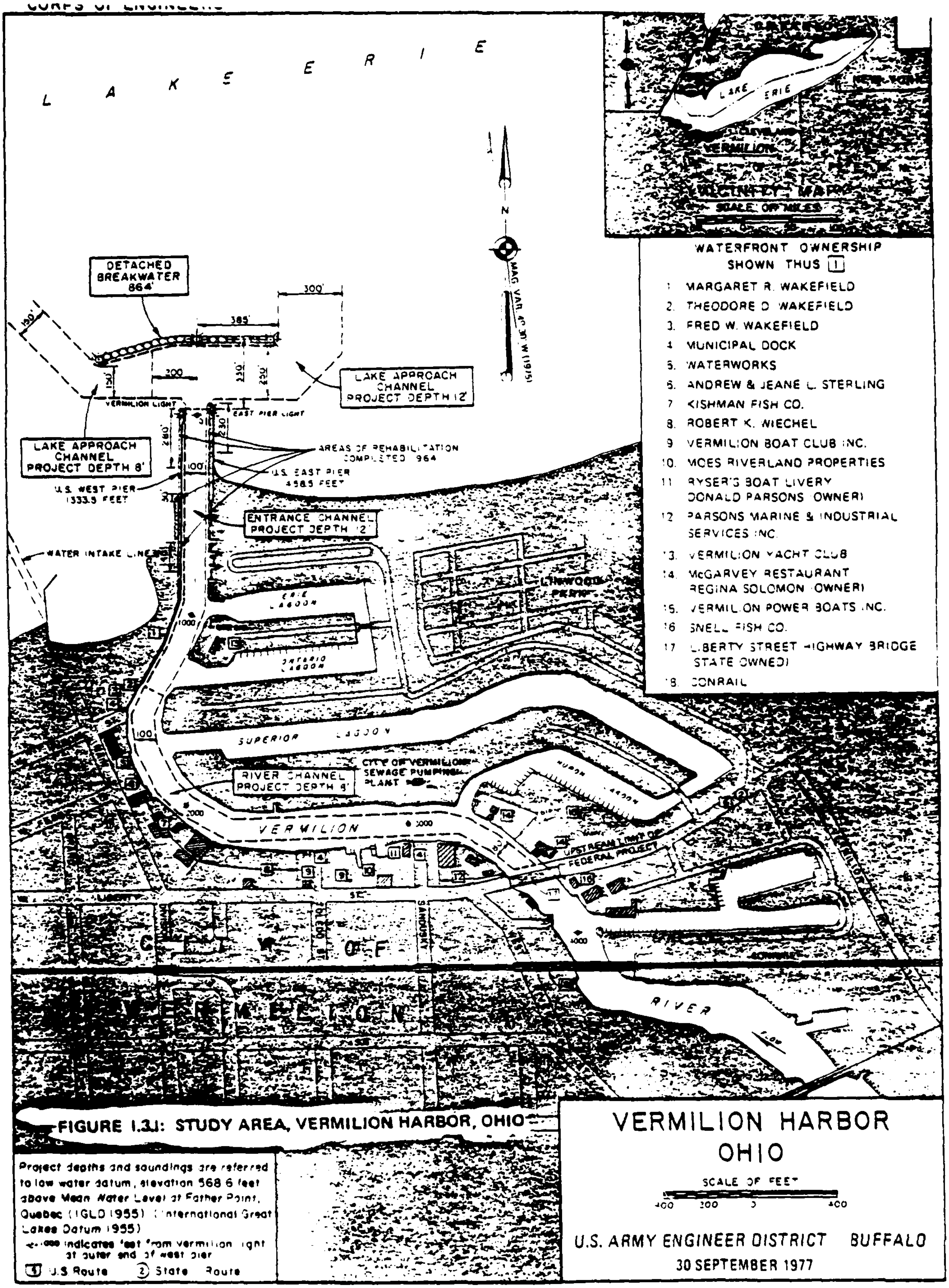


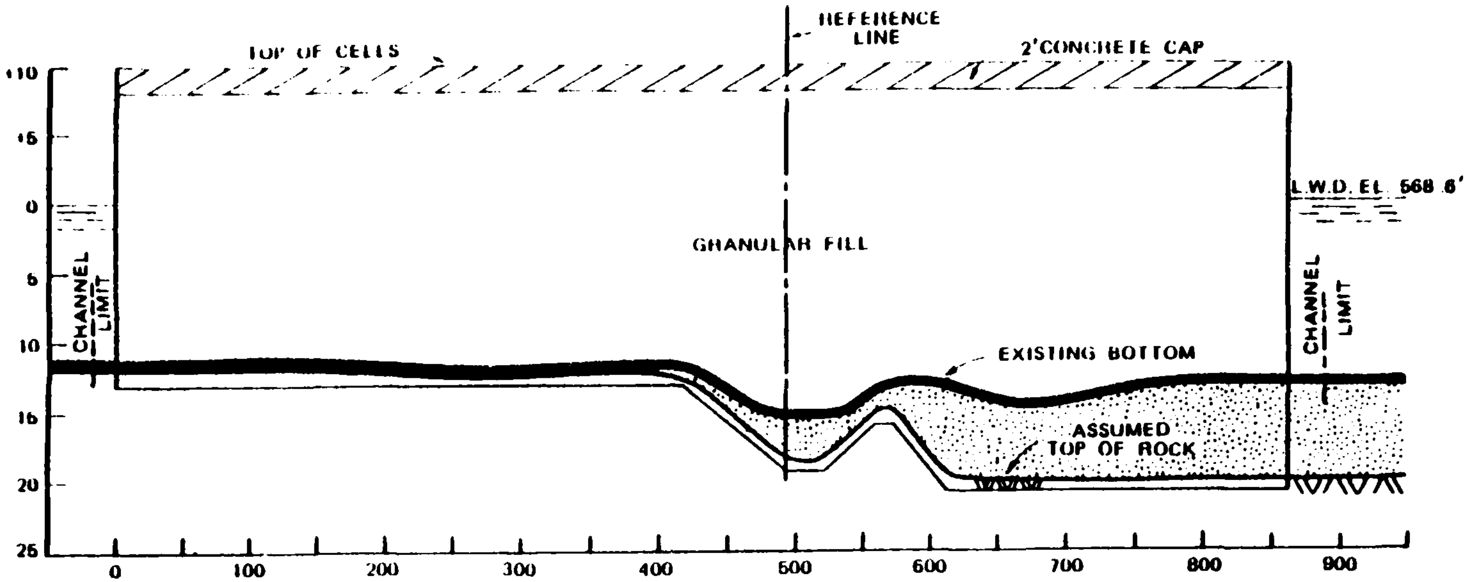
FIGURE 1.3.1: STUDY AREA, VERMILION HARBOR, OHIO

to 1,075 feet and that of the west jetty to 1,125 feet. The pier construction and channel deepening was completed in 1878 except for a small rock area near the inner limits of the west entrance channel.

The position of the lakeward ends of the jetties has not changed since 1878 except for minor alterations during pierhead reconstruction. The Federal government has made frequent and extensive repairs to both piers. Between 1907 and 1914 the entire timber superstructure was rehabilitated with heavy stone, raising the elevation of the piers to 6 to 6.5 feet above low water datum.

To provide safer entrance conditions at Vermilion, and to improve the access channel to the expanding harbor facilities farther upstream, the Rivers and Harbors Act of 1958 authorized construction of overlapping "arrowhead" breakwaters at a distance of about 500 feet lakeward of the outer end of the east pier. The Act also authorized the extension of the 8-foot river channel further upstream. A model study of the proposed breakwater system was completed in 1969. The study, limited to investigating the effects of various structures on wave action, showed that the arrowhead breakwater plan did not provide sufficient wave protection for use of the harbor during all ice-free seasons. A single breakwater, located parallel to shore and about 300 feet lakeward of the outer end of the east pier, was selected as a more effective and economical alternative. In 1973, the Federal government constructed the breakwater, a "T" type cellular structure, and extended the federally-maintained river channel to a point 3,600 feet upstream from the east entrance pier.

The 864-foot long breakwater is aligned generally in an east-west direction. The design of this structure is presented in Figure 1.3.2. The structure consists of 22 circular steel caisson cells with overlapping arcs; each cell is 35 feet in diameter. The sheet piles were driven into bedrock, the cells filled with locally available granular material, and covered with a 2-foot thick reinforced concrete cap. Cleats, light poles, and ladders were installed. The top of the breakwater is 10 feet above Low Water Datum.



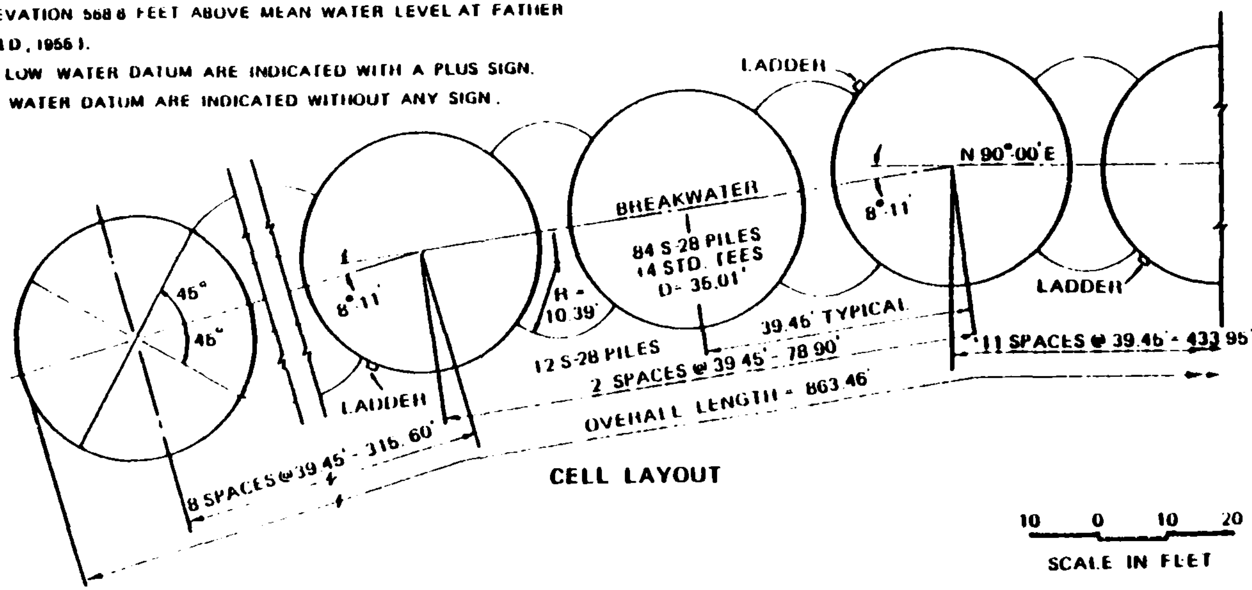
BREAKWATER PROFILE

GENERAL NOTES:

DEPTHS ARE IN FEET AND TENTHS AND REFERRED TO LOW WATER DATUM FOR LAKE ERIE, ELEVATION 568.6 FEET ABOVE MEAN WATER LEVEL AT FATHER POINT, QUEBEC (IGLD, 1955).

ELEVATIONS ABOVE LOW WATER DATUM ARE INDICATED WITH A PLUS SIGN.

DEPTHS BELOW LOW WATER DATUM ARE INDICATED WITHOUT ANY SIGN.



CELL LAYOUT

FIGURE I.3.2 OFFSHORE BREAKWATER DESIGN

During the construction period, approximately 20,000 cubic yards of sediment and 5,700 cubic yards of unclassified material were dredged from the lake approach entrance channel, classified as suitable for open-lake disposal, and deposited in the open-lake dump zone 2 1/4 miles north of the harbor. Sediment dredged from the river channel was classified unsuitalbe for open-lake disposal by the Federal Water Pollution Control Administration (now the U.S. Environmental Protection Agency) and deposited in an upland disposal site located about 3.5 miles south of Vermilion.

Since the breakwater project was completed in 1973, maintenance dredging operations have been performed on six occasions at Vermilion Harbor due to shoaling in the entrance and lake approach channels.

1.4 PRIOR REPORTS

In the early 1950's, the entire Lake Erie shoreline of Ohio was evaluated to determine significant erosion problem areas. This study, presented as House Documents 32 and 229 of the 83rd Congress (1952-1953), presented a qualitative description of shoreline erosion in the Vermilion area. In 1964, a report entitled "Effects of Large Structures on the Ohio Shore of Lake Erie" was prepared by the Ohio Department of Natural Resources. In January, 1976, the Buffalo District of the U.S. Army Corps of Engineers prepared a preliminary Section 111 report that led to the study contained herein. Stanley Consultants (1978) prepared a Section 111 report (Stage 2) in May, 1978, that dealt principally with the shoreline to the east of Vermilion Harbor.

2.0 SHORE PROCESSES

Along the Ohio shoreline of Lake Erie, physical factors of importance which affect the beach and bluff stability include wind, waves, lake level fluctuations, sediment sources, and shoreline configuration. Currents that initiate and sustain longshore sediment movement are generated by wind and waves; the latter being the dominant agent in the transport of sand-sized sediment in the nearshore zone.

Both long-and short-term fluctuations in lake level are central to an understanding of the current processes of shoreline dynamics. Viewed from the framework of geological time, their continued erosion is a natural and expected process. This longterm trend of erosion continues today, becoming intensified during short-term lake level rises when wave impact is exerted directly on the base of the bluff.

Another factor of paramount importance is the nature of the source of littoral material in the study area. Along this section of shoreline, there is no major river outflow which provides littorally suitable sediment from eroding upland terrain. Consequently, the sediment supply along the shoreline is generated almost entirely within the littoral zone through the erosion of the beach bluff and offshore profile.

Bluff erosion is a relatively meager source of supply. Thus because of the low sand and gravel content and the effects of shore protection works, the amount of sediment in the littoral zone available for transport by wave action and longshore currents is small. Survey information indicates numerous areas in the littoral zone where rock material exists without a sand cover. It is likely that these denuded areas have gradually increased over many hundreds of years, or that recent aggravated erosion has been severe enough to decimate the formerly existing thin veneer of sand.

It is possible, as a corollary to the above situation, that the actual rate of sediment transport in the surf zone is considerably less than the amount that would be predicted given the available wave energy due to the

scarcity of sediment available for wave-induced transport within the littoral zone.

Because of a relatively thin veneer of sand on the lake bottom and on the beach, such energy absorbing features as longshore bars and broad sandy beaches are virtually non-existant. Consequently, waves are able to expend considerable portions of their energy near the base of the bluff.

The bluff is primarily composed of glacial till, and its sediments consist mainly of fine silt and clay which, when placed in water following the collapse of the bluff, will be readily washed to the offshore without contributing to the enrichment of the nearshore zone. Field inspections indicate that the coarse fractions (sand and pebbles) represent only about 15% of the total bluff volume; the remainder consisting of clay and silt. Any effort to protect the bluff from erosion inevitably reduces the amount contributed to the littoral zone. Such structural protection has been installed during the past 100 years near Vermilion in various forms such as groins and revetments. Any further efforts to delay and/or prevent bluff erosion will aggravate the already existing deficit of littoral material.

The bluff takes the form of a line source, unlike sediment discharge by rivers which represent a point source. Whereas the benefits of a point source diminish progressively with distance from the source of supply, a line source causes progressive accumulation of littoral material as one proceeds downdrift along the shoreline.

When considering future shoreline change, the bluffed shoreline that comprises virtually the entire study reach to the west of Vermilion Harbor presents a unique situation. Several aspects of bluffline coastal processes, as contrasted to coastal processes along sand shores, are worthy of mention. They are as follows:

1. Bluff erosion occurs as a local phenomenon, represented by a chunk of collapsing bluff with limited alongshore distance. Therefore, although a single episode of bluff erosion may attain quite a high rate in terms of volumetric loss and shoreline recession per event, average rates over a large reach generally yield relatively low amounts.

2. Any loss of bluffline is an irrecoverable loss, whereas a loss of sandy shoreline frequently would occur as part of natural cycles of alternate erosion and accretion. Hence, damage on a bluffed coast has longer lasting implications than damage on sandy shores.

3. The bluff has its own processes of dynamics which are almost entirely alien to the processes lakeward from the shoreline. For instance, the structural integrity of a bluff is a function of such factors as lithology, ground water, vegetation, height, and slopes. Conversely, the topography of sandy shores is in equilibrium with waves and currents, and unlike the bluffed coast, is inherently tied to the underwater topography.

4. The stability of the bluff depends, to a large extent, upon the character of the buffer zone which separates it from forces exerted by the lake. Such a buffer zone is frequently a belt of sandy beach in front of a bluff which absorbs wave energy, thus preventing it from striking the bluff. This sandy beach is not necessarily provided in whole by the bluff erosion, especially where the bluff contains only small amounts of coarse sand as in the study area. In cases such as this, the amount of littoral drift from an updrift reach, capable of supplying sufficient material to nourish a sandy beach in front of a bluff, is a key to stability.

2.2 SHORE AND BEACH CHARACTERISTICS

2.2.1 PHYSICAL FEATURES OF THE SHORELINE

In the immediate Vermilion area, the upper formations of bedrock consist of Huron shales from the Upper Devonian period. These shales form blue-gray to black outcroppings along the lake shoreline and are exposed on the lake bottom both to the east and west of Vermilion. Mineral resources located within the Vermilion River watershed include sand and gravel deposits near Greenwich, located about 35 miles south of Vermilion. Surficial materials in the vicinity of Vermilion Harbor are unconsolidated clay, sand, and gravel deposits laid down either by the Wisconsin ice sheet or in glacial lakes preceding Lake Erie.

The Lake Erie shoreline extending east from the east jetty of Vermilion Harbor consists of about 3,000 feet of sand beach followed by 1,000

feet of rock bluff. The beach is almost 300 feet wide adjacent to the east jetty and tapers to nearly zero at or beyond the east end of Linwood Beach at the base of a steep Huron shale bluff about 10 to 15 feet in height. The bluff gradually rises to about 40 feet above the lake. The beach material east of the harbor is fine to medium sand, with gravel and cobbles prevalent near the water line. The 5-to 12-foot thick top layer of the bluff is glacial material. The shale outcrop extends for about 2 1/2 miles to the east of the harbor, where it dips below lake level, remaining submerged until it rises above water level about one mile east of Lorain. Grain size analysis of the bluff material indicates that only about 12 percent of the material is fine sand or coarser and suitable for natural beach building. The bluff behind Linwood Beach is too short to be a significant beachbuilding source, even though it has a much larger percentage of sand. Where the shale surface is submerged, the coastline is primarily boulder clay overlain with sand deposits with a few small sand pockets.

Immediately west of Vermilion Harbor, a 360-foot reach of private property exists. West of this parcel lie the Vermilion City Beach (220 feet in length) and the Maritime Museum property (330 feet in length). In this area, the Huron shale surface remains close to the lake level. The bluff behind the beach is about 10 feet high and consists of boulder clay overlain with lacustrine deposits. The height of the bluff gradually increases toward the west reaching a maximum height of about 30 feet about 4 miles from Vermilion. The bluffs are nearly vertical and are protected in places by seawalls or short segments of narrow beach impounded between short groins. The bluff generally consists of about equal thicknesses of an upper stratum of fine silt and clay and a lower stratum of boulder clay that contains some coarse granular material. The nearshore lake bottom immediately west of the harbor is hard shale with some cobbles and boulders and occasional small sand deposits. Recent field studies by the Buffalo District show that sediments in the lake approach channels are essentially clay and silt, with some fine sand near the pier ends.

2.2.2 MAN-MADE SHORE STRUCTURES

To the west of Vermilion Harbor, the 11 miles of shore between Vermilion and Huron Harbors is developed almost completely with either permanent

or summer residences. The lakefront of most of these residences has been protected at some time during the past 65 years. Many of the earlier protective structures were stone-filled timber cribs that have recently been reconstructed with concrete superstructures. A complete inventory of shore structures in 1951 indicated 205 individual structures existed between Vermilion and Huron Harbors (U.S. Army Corps of Engineers) an average of one structure for every 283 feet of shore. The majority of the structures were short groins less than 150 feet long, but a few were up to 470 feet in length. At least 10 seawalls or bulkheads over 300 feet long had been built. Qualitative information indicates that additional structures have been added since 1951.

2.2.3 STREAMS NEAR VERMILION HARBOR

The Vermilion River, which rises in northern Ashland County, Ohio, and follows a general northerly course for about 45 miles, drains a 272 square mile area. The river enters Lake Erie through Vermilion Harbor. About two miles above its mouth, the Vermilion River is 100 feet to 200 feet wide with natural depths generally less than three feet. In the lower mile, natural depths range to 10 feet. The Federal government deepened the channel upriver to Ontario Lagoon to a depth of 12 feet in 1973. The channel depth is maintained to 8 feet from that point for a distance of 3,600 feet upstream from the end of the east piers. High flows in the river during flood stages provide scouring velocities in the lower reaches of the river and, before the channel was deepened in 1973, very little dredging was required to maintain a usable channel. Except where beach sand washes over the east jetty into the channel, the sediment in the lower channel is mostly silt and mud. The Vermilion River is not a significant source of beach building sedimentary material.

The only sizable stream entering the lake to the east between Vermilion and Lorain Harbors is Beaver Creek, which rises only 11 miles inland and has a drainage area of about 60 square miles. This stream delivers a negligible amount of beach building material.

The Black River, which enters the lake at Lorain Harbor, does not carry a significant sand-sized sediment load. Maintenance dredging operations are conducted annually along the lower three miles of this river thus removing any sediment before it reaches the littoral zone.

West of the west pier of Vermilion Harbor, several small streams enter the lake between Vermilion and Huron. Previous studies have indicated that these streams contribute negligible amounts of sand-sized sediments to the Lake Erie coastal zone.

2.3 PHYSICAL FORCES

2.3.1 WAVES

Wave impact comprises the dominant force in shoreline erosion. Wave action closely follows wind action on Lake Erie although the swell occasionally persists for 24 hours after a long storm. Wave activity on Lake Erie during storms is often violent and causes rapid shore erosion as well as swift longshore currents.

At Vermilion, the larger, steeper waves, created by strong northeast and northwest winds, are the most effective in eroding and moving sediments. Large sections of the bluff near Vermilion, weakened by wave undercutting, frequently fall to the beach or into the water where wave action sorts the bluff material thereby removing the fine material. Unprotected bluffs normally do not attain a stable slope and the process of sloughing, removal, and undercutting by wave action is continuous. The rate of bluff loss depends to a large extent on lake levels and the related intensity of wave attack.

Table 1 shows wave data developed by the Corps of Engineers utilizing wind data recorded at Lorain Harbor and methods described in the Coastal Engineering Research Center's Shore Protection Manual.

TABLE 1 WIND AND DEEP-WATER WAVE CHARACTERISTICS

Fetch		Wind		Waves	
Direction	Distance miles	Velocity miles/hour	Duration hours	Height feet	Period seconds
West	20	50	20	9.0	6.5
Northwest	50	42	12	9.0	7.5
North	50	35	12	8.5	7.0
Northeast	100+	35	24	11.0	8.0

[1] From: Corps of Engineers, Stage [illegible] Report, January 1975.

The effect of the wave energy on the Vermilion shoreline depends on the wave height and angle of wave attack. Wave refraction, diffraction, and shoaling affect the wave as it approaches the shoreline.

A wave refraction study developed for design of the offshore breakwater in Vermilion Harbor disclosed no unusual patterns of convergence or divergence of wave energy due to irregularities of the bottom contours (U.S. Army, Corps of Engineers, 1971).

Wave diffraction, which allows for the lateral transfer of energy along the wave crest, is most noticable when the progress of waves is interrupted by some barrier, such as the detached breakwater and harbor entrance jetties at Vermilion. Diffraction of waves around these structures also affects the wave angle and height. Wave diffraction can affect all of the Vermilion City Beach area to the west as well as the shore for a distance of 1,200 to 1,400 feet to the east of the east jetty.

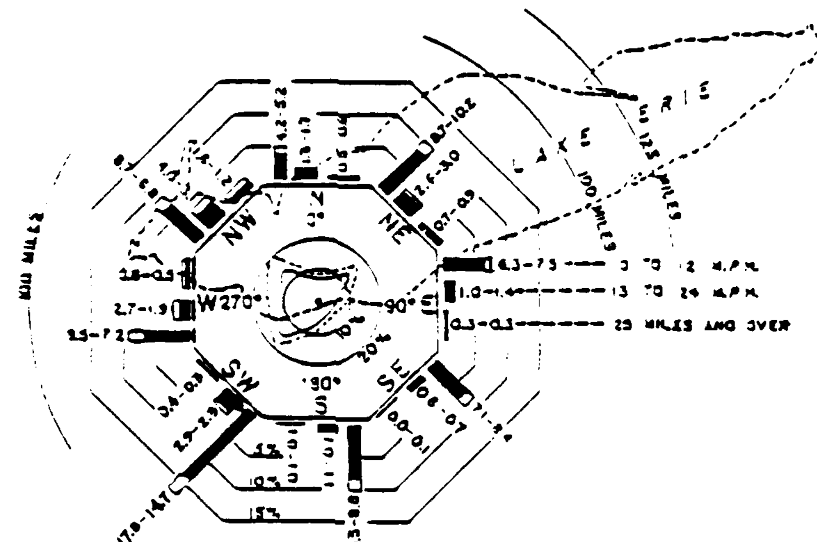
2.3.2 WINDS

Observed wind data are not available for Vermilion Harbor, however, data for Lorain, Ohio, the site of the nearest weather station, are provided in Figure 2.3.2.1.

The north to west-northwest winds vary widely in intensity from severe storms (winds in excess of 60 mph) to light and moderate summer breezes. Northeast and east winds also range in intensity from light summer breezes (5 mph to 10 mph) to storm speeds (40 mph to 50 mph); passage of frontal systems frequently results in sustained northeast winds to 15 mph to 25 mph for two or three days. The most frequent winds in the Vermilion area are southwesterly winds.

2.3.3 CURRENTS

Nearshore currents in Lake Erie consist of the very weak natural flow of water through the Great Lakes system. Wind-driven currents can achieve velocities of up to 2 feet per second. Littoral currents generated



SOURCE : STANLEY CONSULTANTS , 1978

NOTES

INDICATES DURATION FOR ICE-FREE PERIOD (MAR. TO DEC. INCL.) IN PERCENT OF TOTAL DURATION.

INDICATES DURATION FOR ICE PERIOD (JAN. TO FEB. INCL.) IN PERCENT OF TOTAL DURATION.

INDICATES PERCENT OF TOTAL WIND MOVEMENT OCCURRING DURING ICE-FREE PERIOD.

INDICATES PERCENT OF TOTAL WIND MOVEMENT OCCURRING DURING COMBINED ICE AND ICE-FREE PERIODS.

FIGURES AT ENDS OF BARS INDICATE PERCENT OF TOTAL WIND DURATION FOR ICE-FREE PERIOD AND COMBINED ICE-FREE AND ICE PERIODS, RESPECTIVELY.

WIND DATA BASED ON RECORDS OF THE U. S. COAST GUARD AT LORAIN HARBOR, OHIO FOR PERIOD 1 JAN. 1938 - 31 DEC. 1967

FIGURE 2.3.2.1. : WIND DIAGRAM , LORAIN HARBOR , OHIO

by breaking waves in the surf zone can create velocities up to 4.0 feet per second. Some currents can be generated from water inflow from a stream or river. The nearshore currents near Vermilion are influenced primarily by the wind, the bottom topography, and inflow from tributaries.

The Great Lakes flow-through current near Vermilion is immeasurably slow because of the large cross-section of the central basin of Lake Erie. Circulation is controlled by the wind, and reversals are common with wind shifts. The predominant surface water movement is eastward due to the prevailing westerly winds. Littoral currents in the Vermilion area generally move from east to west. Near the mouth of the Vermilion River, the hydraulic gradient of the river is very low, resulting in very low stream velocities during all but high river flows.

Current studies conducted in May through September 1977 indicate that the breakwater limits the northerly motion of the river water, creating current patterns similar to those of prebreakwater conditions during periods of strong northwesterly winds (Stanley Consultants, 1978).

2.3.4 LAKE WATER LEVEL

Shoreline conditions can be altered extensively by lake level changes. A beach profile is generally concave upwards. A rise in lake level along a concave profile causes the beach face to be readjusted by the waves to a flatter slope resulting in erosion above the water line and some accretion offshore as the beach profile adjusts to the new lake level. (see Figure 2.3.4.1).

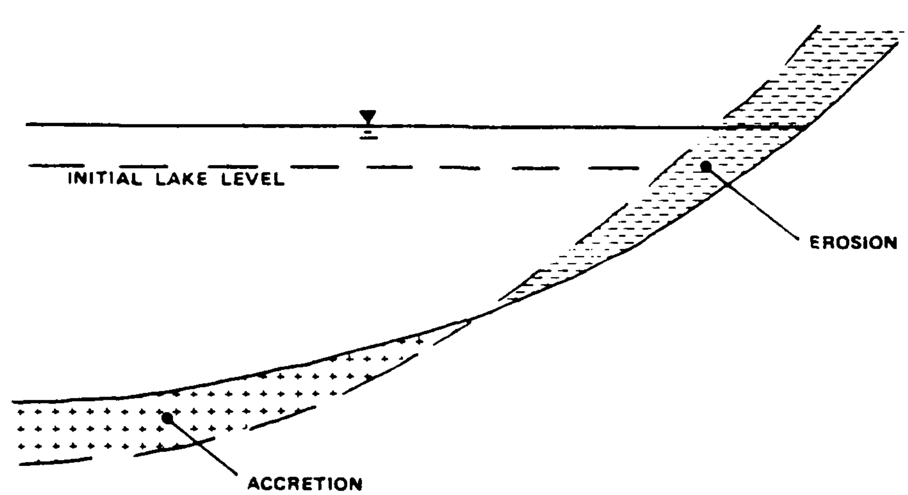


FIGURE 2.3.4.1.: NEARSHORE EFFECTS OF LAKE LEVEL RISE

Conversely, a fall in water level on a concave beach profile eventually leads to a steepening of the beach face as the readjustment by waves builds a berm. (see Figure 2.3.4.2).

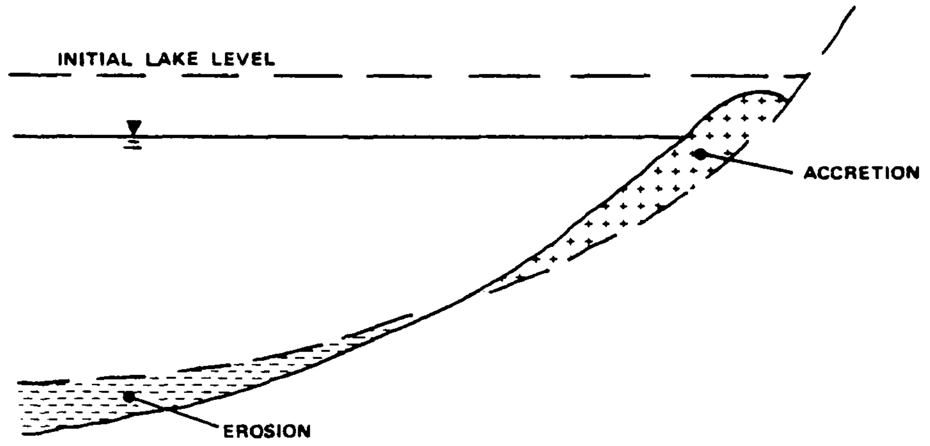


FIGURE 2.3.4.2: NEARSHORE EFFECTS OF LAKE LEVEL FALL

The effects of rising and falling lake levels do not balance. High levels permit waves to erode the high bluffs whereas during lower lake levels these features will not be replaced. Also, because sediment moves more easily in the surf zone than in offshore waters, the beach face is readjusted fairly quickly while the offshore areas readjust much more slowly. In addition, there is a continual loss from the system to offshore areas.

The water levels of the Vermilion Harbor area are essentially the same as the levels of Lake Erie. The average or normal lake level varies irregularly from year to year, and is subject to a consistent seasonal rise and fall (the highest levels prevailing during the summer months and the lowest during the winter months). The level of Lake Erie is measured relative to the Low Water Datum of 568.6 feet above the International Great Lakes Datum (IGLD) established in 1955. In the 118 years from 1860-1977, the level of Lake Erie has fluctuated from a high

monthly mean of 573.51 feet (June, 1973) to a low monthly mean of 567.49 feet (February, 1936). The greatest annual fluctuation, as determined by the highest and the lowest monthly mean of the year was 2.75 feet, and the least annual fluctuation was 0.87 foot. During the 1973 to mid-1979 period, the maximum monthly mean stages have ranged from 3.42 feet (February 1977) to 4.9 feet (June 1973) above low-water datum. The minimum monthly mean stages have ranged from 1.6 feet (February, 1977) to 3.2 feet (November, 1973) above low-water datum.

Table 2 presents a tabulation of Lake Erie water level data. The fluctuations shown in Table 2 are produced by rainfall and runoff in the Great Lakes basin and are reasonably predictable only 4 to 6 months in advance. Seasonal cycles produce variations of 1 foot to 2 feet with the highest annual elevations in June and July.

In addition to annual and seasonal fluctuations, storms produce water level changes due to barometric pressure changes or prolonged strong winds. Wind induced "set-up" results when strong winds induce water flow toward the leeward shore, thereby increasing the water level at that location. This effect can result in short-term water level increases of up to two feet at Vermilion. The highest short-term water levels occur during northeast storms, which yield a westerly flow of sand in the littoral zone during such periods.

The orientation of the shoreline is not affected significantly by variations in water level unless refraction of the waves is altered--that is, unless irregularities in bed topography are flooded/exposed by the water level rise/fall. Such irregularities are not significant at Vermilion since the bed is formed by relatively parallel bottom contours. Hence, variation in lake level does not significantly alter the angle of waves breaking on the beaches at Vermilion.

TABLE 2:

LAKE ERIE LEVELS, 1860 – 1977

DATE	MEAN ELEVATION (IGLD)*, FEET	VARIANCE FROM LOW WATER DATUM, FEET -
Long-term		
1860-1977	570.36	+1.76
Yearly Mean		
1968	570.92	+2.32
1969	571.54	+2.94
1970	571.10	+2.50
1971	571.27	+2.67
1972	571.89	+3.29
1973	572.71	+4.11
1974	572.52	+3.92
1975	572.27	+3.67
1976	572.10	+3.50
1977	571.24	+2.50
Highest Monthly Mean Level		
June 1973	573.51	+4.91
Lowest Monthly Mean Level		
February 1936	567.49	-1.11

* IGLD = International Great Lakes Datum
- Low Water Datum is 568.6 Feet (IGLD)

(From: Stanley Consultants, Vermilion Harbor, Ohio Section 111 Study, May 1978)

2.3.5. ICE

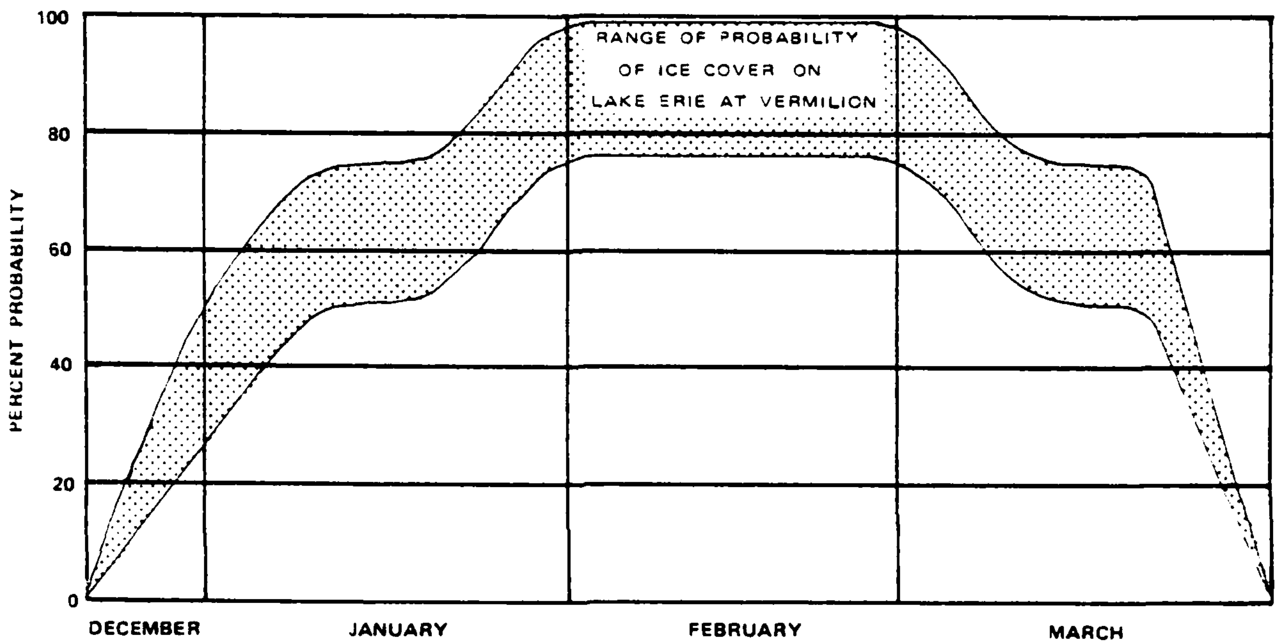
Ice conditions around Vermilion may differ significantly from year to year, and even during any given winter. Ice formation at Vermilion Harbor depends on the complex interaction of many physical factors such as air and water temperature, wind, waves, water currents, water depth, and shoreline configuration. Shore ice can provide a protective barrier between the vulnerable beach or bluff and the incoming wave energy. Figure 2.3.5. gives an indication of the expected periods of ice cover at Vermilion Harbor. These periods of ice formation have been noted in undertaking the littoral transport analysis in this report. During periods of shore-fast ice cover, littoral drift has been assumed to be negligible.

2.4 LITTORAL SEDIMENTS

2.4.1. SOURCES OF SEDIMENT

The process of erosion/accretion of a beach depends on a balance of the existing hydraulic factors and the supply of sediment to the littoral system. The possible sources of sediment for the Vermilion area shoreline are the Vermilion River, offshore deposits, or bluff erosion. Because Vermilion River sediments are primarily fine-grained silt and clay, the river is not a significant source of beach sand. Offshore deposits of any magnitude apparently do not exist in the nearshore areas off Vermilion. The only major sediment source for the Vermilion shoreline appears to be from bluff erosion.

The amount of beach building sand generated by bluff erosion varies greatly due principally to wave action and storm related water level rise. The reach of coast that supplies sand to the beaches to the east of Vermilion Harbor is about five miles in length. The harbor structures at Vermilion act as a virtual barrier to littoral transport



SOURCE: STANLEY CONSULTANTS, 1978

FIGURE 2.3.5.: PROBABILITY OF ICE COVER, VERMILION, OHIO

along the coast. Some of the area to the west is already protected by natural or man-made barriers, but estimates indicate that about 50 to 60 percent of the area is actively eroding; previous studies have shown that the long-term recession rate of this shoreline stretch exceeds 1 foot per year. (Ohio Department of Natural Resources, open File Map 89, 1975).

2.4.2 SEDIMENT COMPOSITION

In the outer Vermilion harbor, the sediments consist of a thin mantle of sand, clay, and gravel of medium density overlaying a rock basement. The sediment veneer thickens at the eastern end of the breakwater. Over portions of the west harbor entrance, no surficial sediment exists.

Between the piers, the river channel exhibits sediments that vary in size and character from sandy silts to silty clay. Dredging has exposed rock at the downstream end. The sediment thickness upstream varies in response to alternating periods of scour and deposition during high river flows. Beach sand once overtopped the east pier and contributed to shoaling in the river channel. Since the raising of the pier elevation in 1974, however, overtopping of the pier structure by beach sand has ceased. Sediment deposited in the area between the river piers and the detached breakwater includes silt and clay-sized particles from the river. The presence of sand immediately northeast of the end of the east pier indicates that beach or lake bottom material is being transported to this area.

Sediment in the Vermilion River upstream from the piers consists of silt and clay-sized particles. The organic content of this material is higher than that found in the harbor approach area. (U.S. Army Corps of Engineers Survey Data, 1980).

2.4.3 SEDIMENT TRANSPORT

Littoral material is continually moved by waves in the nearshore area. Steep waves under an onshore wind tend to erode the beach face. A portion of the material which is suspended during these events is carried

offshore. During times of reduced wind and wave energy, longer period waves tend to push sediment shorewards thereby building the beach. Offshore erosion dominates over onshore accretion along the south shore of Lake Erie because storm waves are almost always short-period seas accompanied by onshore winds. Waves without winds imply a distant storm generating waves which propagate out of the storm as long-period swell. The Great Lakes coasts have much less swell than ocean coasts due to limited fetch length, hence the dominance of erosion is generally higher than for an ocean coast.

The direction of longshore littoral transport in the Vermilion area exhibits an east to west predominance. Shoreline orientation along Lagoon Beach and Linwood Beach is roughly east-west (80^{0} to 100^{0} from north). The net longshore energy fluxes at Vermilion are very small, and a slight difference in shoreline alignment may change the direction of littoral movement. The waves responsible for sediment transport at Vermilion are predominately those originating in the northeast and northwest directions.

The longer fetch distances to the north and northeast across Lake Erie allow larger waves to develop than those that can develop over the shorter fetches from the west and northwest. Accordingly, greater total wave energy is directed westerly. Nevertheless, a small sand beach that has accumulated along the shoreline immediately to the west of Vermilion Harbor is evidence that reversals of current and drift from the predominant east-west to a west-east direction do occur. The wind pattern on Lake Erie confirms the likelihood of frequent reversals in the direction of littoral drift.

A recent report by Stanley Consultants (1978) has shown that even small onshore-offshore movements can significantly affect the sediment budget due to the relatively small amounts of material involved.

The flow of sand around the ends of the Vermilion Harbor piers prior to the construction of the offshore breakwater is believed to have varied between 1,000 to 4,000 cubic yards of sand per year. Evidence indicates that westerly sand transport around the piers has decreased since the construction of the breakwater. During this period, dredging of the sediments deposited

in the river and lake approach channels has been required on six occasions.

Since completion of the breakwater, survey data indicates that there has been a sediment buildup along the pier at the east edge of the river entrance channel and sediment buildup in the eastern lake approach. Sediment buildup in the east and west lake approach channels is greatest along the shoreward side of the channel near the pier ends. The east lake approach channel is more than 250 feet wide along the breakwater where the channel depth is greater than 12 feet. The beach immediately east of the east pier has accreted since 1973. Some of the sand is moving offshore into the lake approach channel and is being lost from the system due to channel dredging operations.

3.0 SHORELINE CHANGE ANALYSIS

3.1 INTRODUCTION

The methods of analysis used to determine long-and short term changes along the reach of shoreline under study are as follows:

1) Bathymetric Map Comparison: Erosion or accretion in the nearshore zone can have a major impact on the stability of the shoreline. Knowledge of the lakebed composition (sand, clay, rock, cobble, etc.) gives an indication of the ease with which lakebed erosion can occur. Comparison of soundings must be judged only after a proper assessment has been made concerning the accuracy of each individual survey. Bathymetric survey methods have varied considerably in this regard over the past 100 years. For this reason, it is wise to disregard minor changes in the bottom profile and stress only those changes that exceed the range of survey inaccuracies.

2) Historical Map Comparison: The only way to measure changes in the shore and bluff dating back to the mid-1800's is through the interpretation of old maps and charts. Prior to 1930, aerial photographs were not used routinely to accurately delineate topographic features to be mapped. Therefore, some inaccuracy in positioning is expected in documents produced prior to that time. Nevertheless, the general trends of shoreline change that can be gleaned from early maps provide very useful information on the effect that modern-day shore protection structures have on littoral processes.

3) Aerial Photographs: The most valuable technique available to assess shoreline changes is aerial photo analysis. These photos are available for periods following 1930 for virtually the entire coast of the United States.

This data source is used to define recent shoreline trends and, specifically, the effect that individual coastal structures have on shore stability.

3.2 LIMIT OF SHORELINE INFLUENCE OF FEDERAL NAVIGATION WORKS

When studying a coastal system which includes a major littoral barrier, one would expect to find a zone downdrift of the structure where excessive erosion has taken place followed further downdrift by zones of decreasing erosion until "normal" littoral conditions are predominant. At Vermilion, the situation is complicated by the following conditions:

1) The original navigation works were installed in 1836 (nearly 150 years ago).

2) Beginning long ago, the residents west of the harbor were obligated to protect their shoreline by armoring it against wave attack.

3) As the city of Vermilion grew to the west with time, the newer residents suffered the effects of both sediment blockage at the harbor piers as well as the dwindling near-shore sand supply caused by the updrift armoring of neighboring properties. These new residents were forced to protect their shoreline and the effects cascaded down the coast to the west.

4) At Sherod Park, however, the shoreline is publically owned and was unprotected. The effect of the sediment blockage at Vermilion Harbor diminishes at this location but the problem of decreased littoral supply caused by armoring of the updrift shoreline persists.

A qualitative estimate of the length of shoreline influenced by the Federal navigation structures at Vermilion has been made. The major tool utilized in the assessment has been observation of the general shape of the shoreline in this region. Figure 3.2.1 shows the U.S. Geological Survey Topographic Map of the present shoreline. A section of shoreline to the west of Vermilion (identified as Zone "A") has been recessed into the shore considerably more than the shore further to the

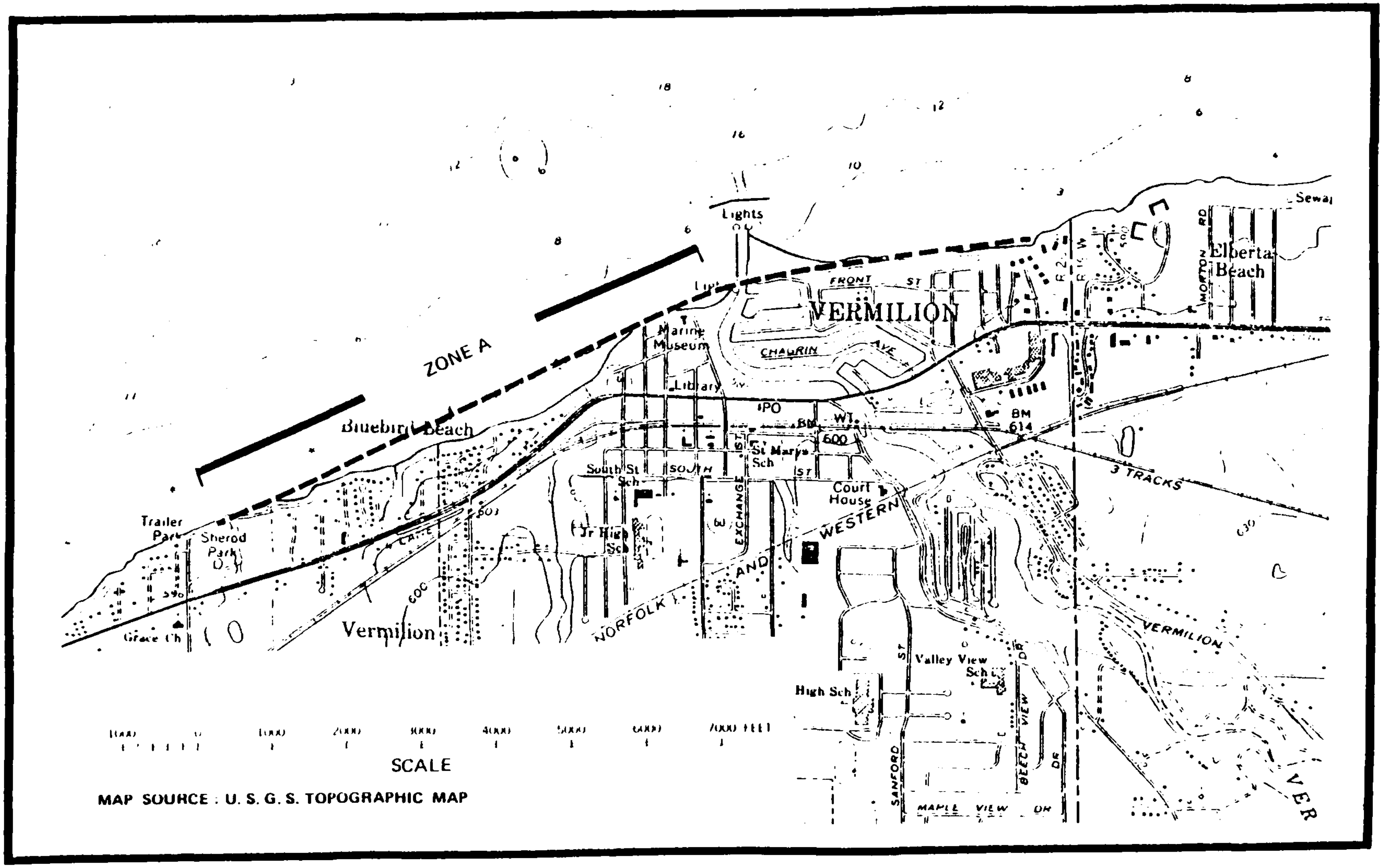


FIGURE 3.2.1 LIMIT OF SHORELINE INFLUENCE, VERMILION HARBOR NAVIGATION STRUCTURES

west. This is believed to be indicative of the increased trend towards erosion in this area due to sediment blockage at the harbor piers.

The dashed line shown in Figure 3.2.1 gives an indication of the assumed shoreline position had there been no coastal structures to control shoreline migration. This line assumes that reaches of the shore are equally subject to erosion and that the Vermilion River does not contribute a significant volume of beach-building sediments to the littoral stream. Utilizing this approach, an 8100-foot length of shoreline to the west of Vermilion Harbor is judged to be affected by the navigation works. This sector is bounded on the west by Coen Road. The area of influence to the east of this harbor is also noted in Figure 3.2.1. In this sector, shoreline growth has occurred in response to the blockage of westerly flowing sediment by the harbor structures.

3.3 BATHYMETRIC MAP COMPARISON

The earliest available bathymetric chart of the Vermilion Harbor region was published in 1877. This is approximately 40 years after the construction of the Vermilion Harbor piers. Numerous lake bottom sediment samples were taken during this survey in order to provide information to the mariner for anchoring purposes. Inspection of the lakebed information contained in the 1877 chart shows that large areas of lakebed at that time had no surficial sand cover. This general condition is illustrated in Figure 3.3.1. (The 1877 lakebed composition is superimposed upon the 1979 basemap). The denuded condition of the lakebed to the west of Vermilion Harbor in 1877 is clearly evident in this figure. During this same period, the lakebed to the east of Vermilion was covered entirely by sedimentary material. A portion of the loss of surficial sand to the west was due, undoubtedly, to the Vermilion Harbor piers that had caused a partial blockage to westerly

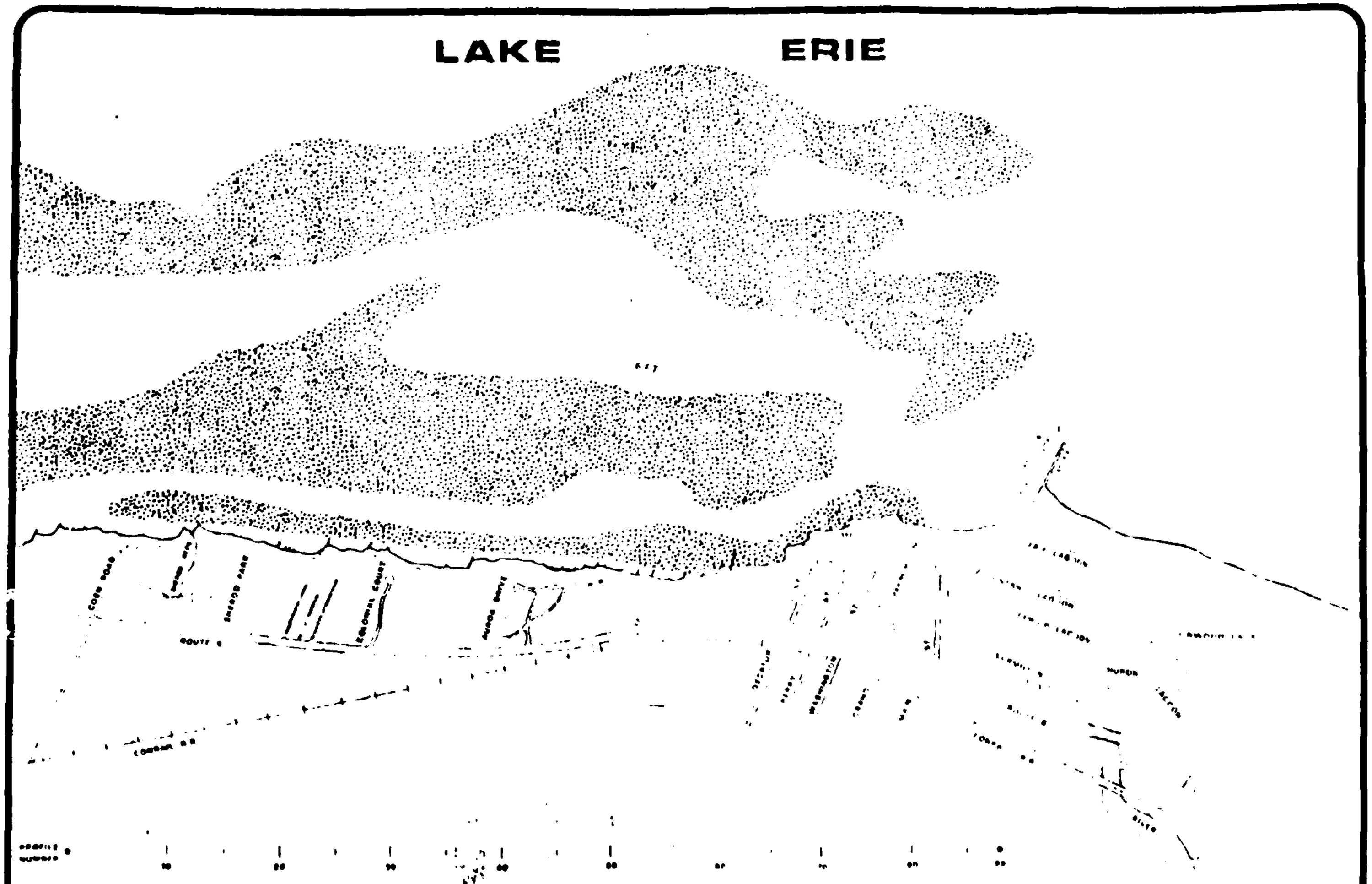


FIGURE 3.3.1.
VERMILION HARBOR, OHIO

LAKEBED COMPOSITION, 1977

TETRA TECH
Pasadena, California

flowing littoral material during the period following the Vermilion pier construction. Indications are given by this data that the thickness of the surficial sediment cover in this general vicinity was fairly minimal in 1877 and a chart of 1961 together with other survey data shows that virtually the entire offshore zone to the east and west of the harbor has been stripped of any significant sediment cover during the past 100 years. Thus, most of this area of lakebed can be considered to be composed of rock and cobbles that provide a very resistant bed material -- one that is armored against future erosion and holds no significant supply of sand available for natural beach replenishment.

Bathymetric charts of 1877 and 1961 have been compared to provide an understanding of profile changes that have occurred during this 84 year period. Figure 3.3.2 is presented to show the extent of the bathymetric net change that has occurred between the two surveys. These data show that while isolated regions of significant sediment accretion have occurred, the largest portion of the offshore zone has undergone no major adjustment during the period 1877-1961. One small area of erosion has also been identified. It is apparent that the lakebed to the west of the harbor in 1877 was relatively resistant to erosion due principally to the rock and very coarse material that covered the bottom at that time.

Recent trends of change of lakebed elevation near Vermilion Harbor were investigated using the precise bathymetric charts that have been prepared by the Corps of Engineers. Figure 3.3.3 shows the 6, 12, and 18 foot contours for the surveys of 1935, 1946, 1967, and 1977. The area to the east of the harbor entrance shows major lakebed elevation changes within the zero to six foot water depths during the past 40 years. To the west of the harbor, however, the bottom contours appear to have undergone very little change. The fact that the contours of the different surveys do not overlay perfectly is probably due to the inaccuracies associated with the different techniques employed in the various surveys.

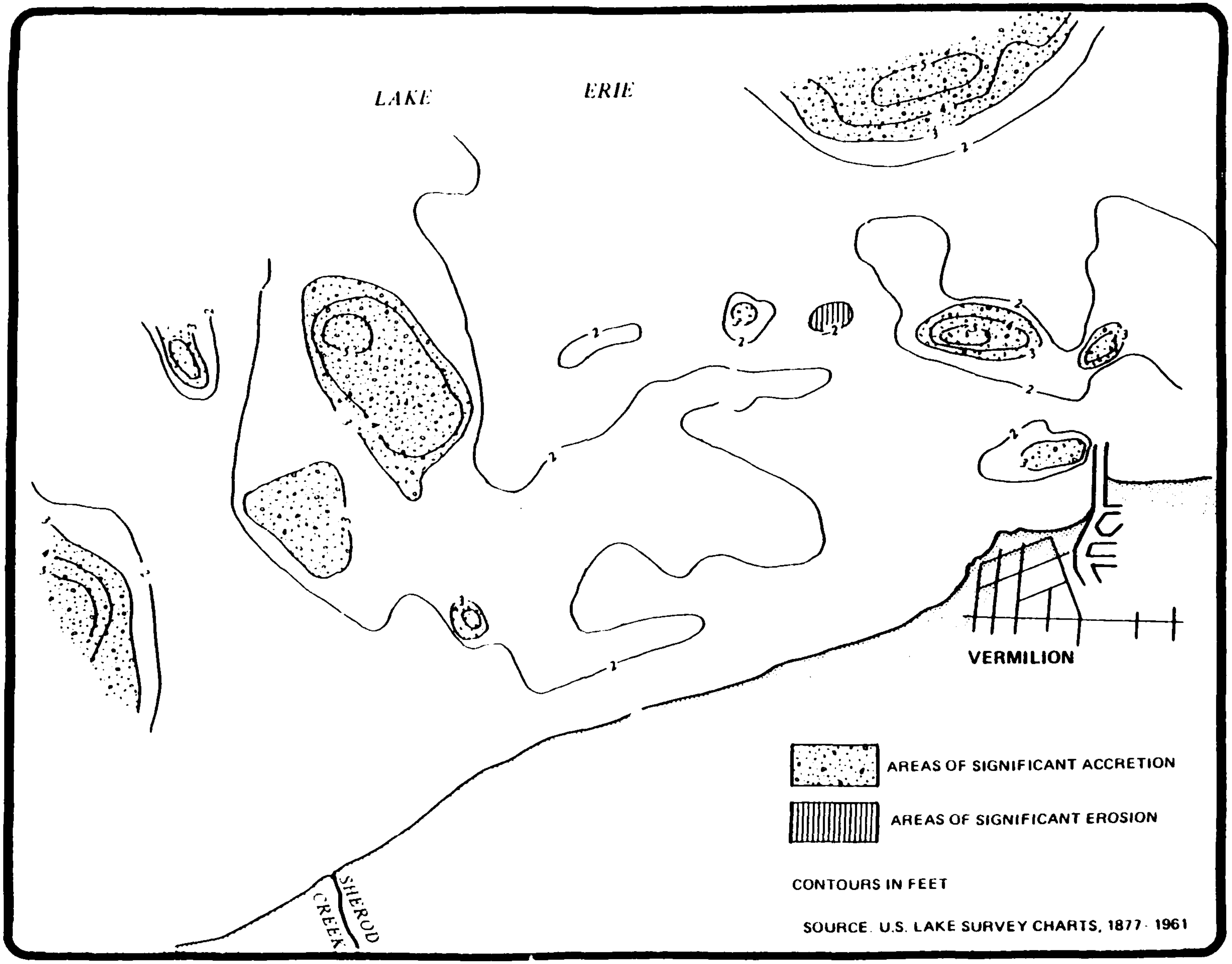


FIGURE 3.3.2 BATHYMETRIC NET CHANGE, 1877–1961

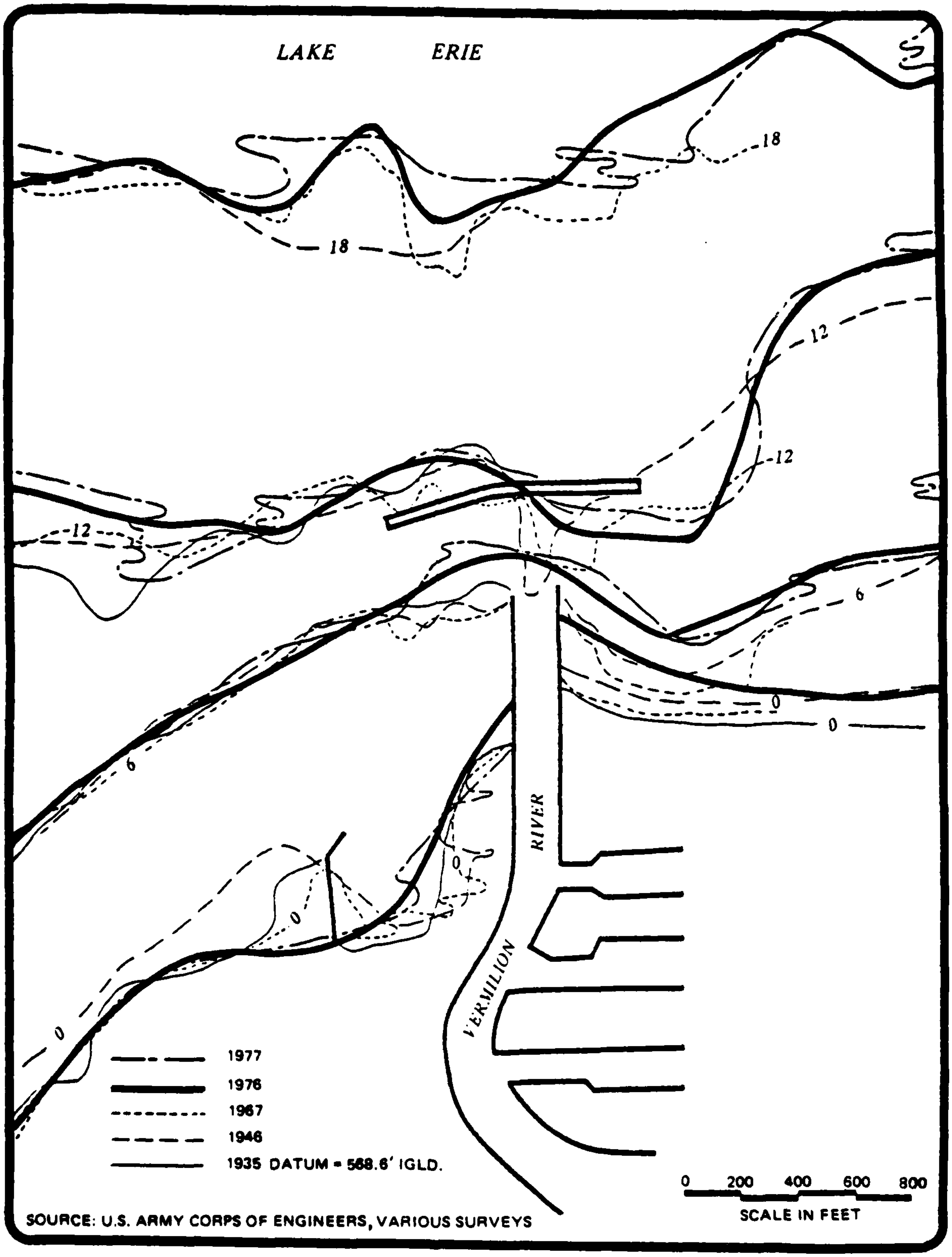


FIGURE 3.3.3 NEARSHORE BATHYMETRY, 1935–1977

Stanley Consultants (1978) has recently compiled bathymetric data to analyze the nearshore change in the bottom profile to the east of Vermilion Harbor. The location of the individual profile lines used in the comparison is shown in Figure 3.3.4. The volumetric change in the nearshore zone follows in Figure 3.3.5 for various time intervals both before and after the breakwater construction of 1973.

The data shows that during the period 1937-1971, a general erosional trend existed in the profile on the east side of the harbor with a small accretional zone located 600 feet west of the west harbor pier. In 1971, a period of major profile accretion began in the region directly to the east of the east pier. This marked a major reversal of the past trend and was caused by updrift erosion induced by the high lake level of the 1971-1973 period. This occurrence of significant accretion at the east pier began prior to the construction of the offshore breakwater.

The data for the 1973-1974 period indicates a continued re-adjustment of the offshore profile towards accretion at the east pier and erosion along Linwood Beach. The annual rate at which sediment accumulated at the east pier in the year following the breakwater construction exceeded that of the 1971-1973 period by a factor of 3. The profile adjustment precipitated by both the high lake level and the construction of the offshore breakwater appeared to be short-lived and the period 1974-1978 saw a dramatic decrease in the amount of profile accretion at the harbor piers. This implies that the beach required about 2 years to stabilize following breakwater construction. Similarly, the trend towards erosion at Linwood Beach during the early 1970's has subsided, and mild accretion has predominated during the 1974-1978 periods along the eastern portion of the beach. Directly to the west of the harbor piers, nearshore accretion has predominated since 1973. This is not due solely to natural littoral processes, however, since mechanical bypassing procedures delivered approximately

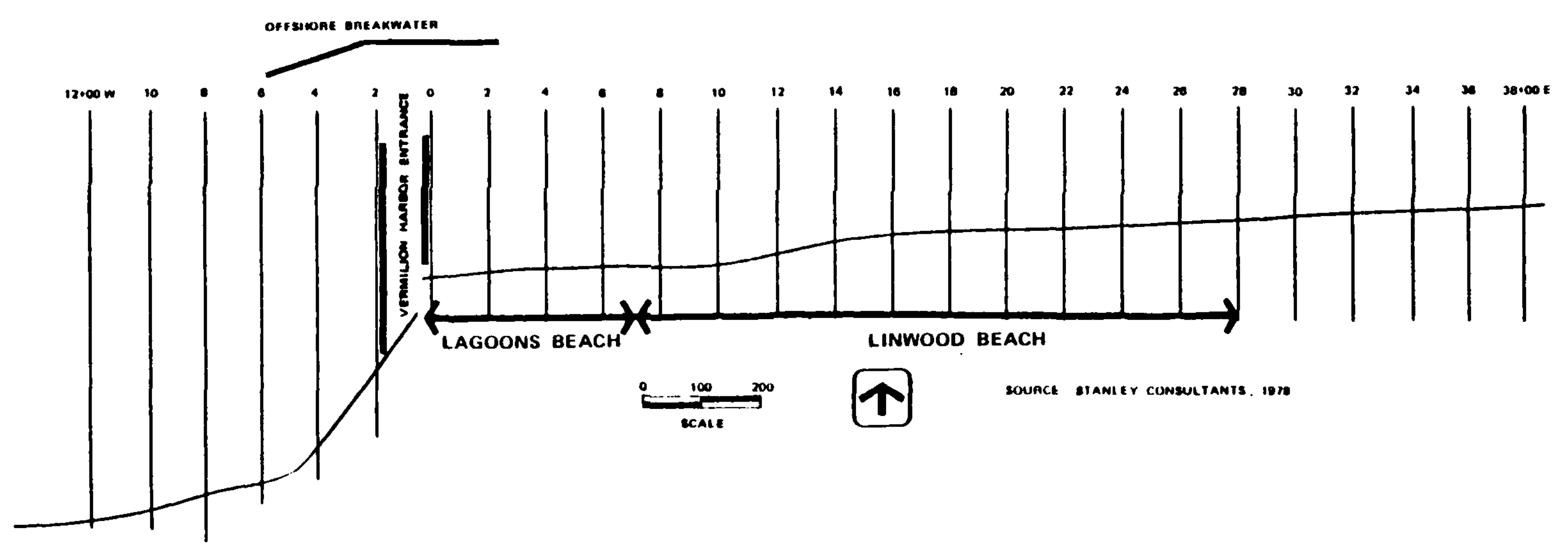
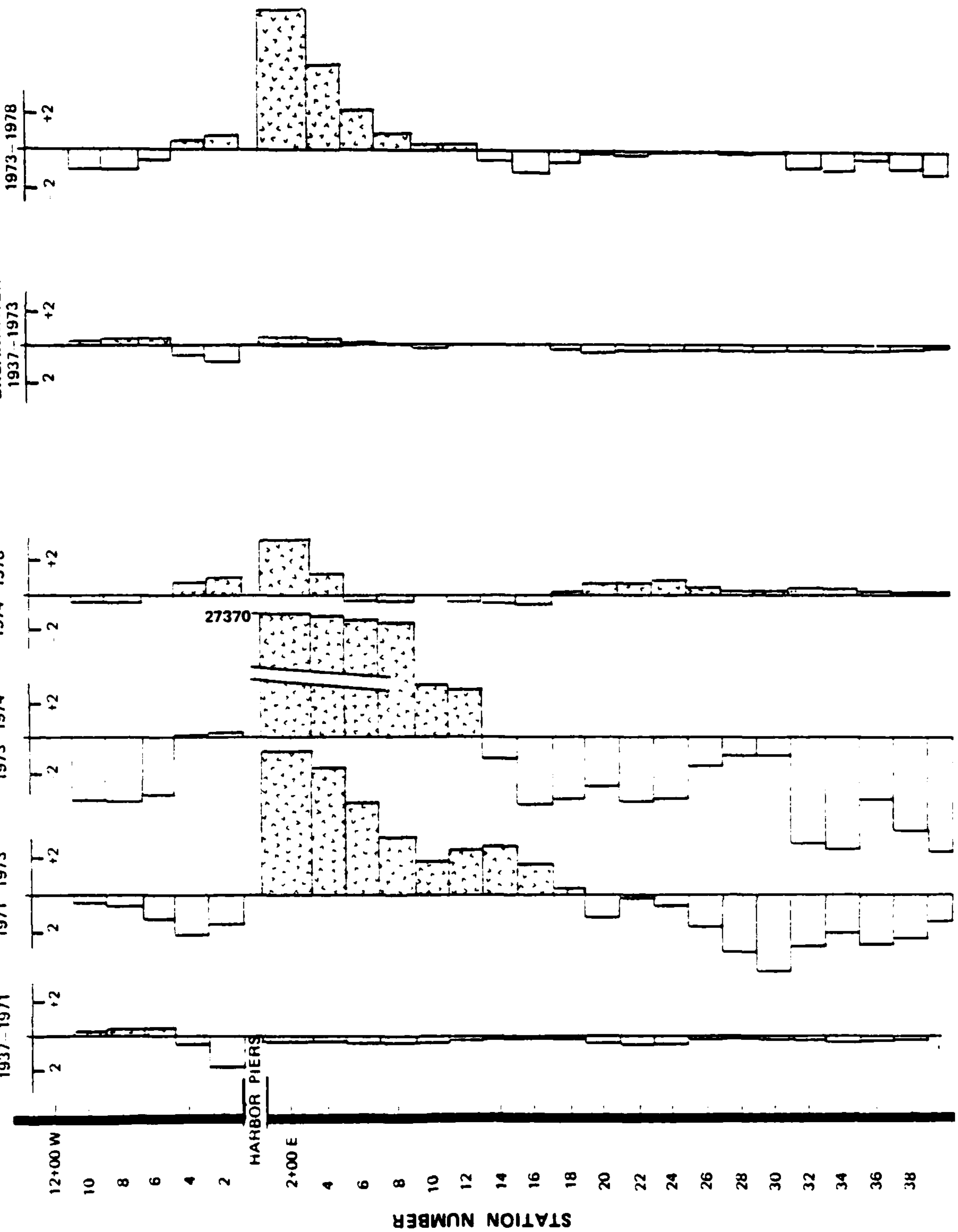


FIGURE 3.3.4.: PROFILE LINES, BATHYMETRIC CHANGE ANALYSIS

FIGURE 3.3.4 PROFILE LINES, BATHYMETRIC CHANGE ANALYSIS

FIGURE 3.3.5: NEARSHORE VOLUMETRIC CHANGE*, VERMILION HARBOR, OHIO



* (1000 C.Y. / YEAR)

SOURCE : STANLEY CONSULTANTS (1978)

2000 cubic yards of sand to this location in 1975 (Buffalo District, personal communication).

Combination of these data allows the presentation of the pre- versus post-breakwater bathymetric profile change. In the pre-breakwater period (1937-1973), mild accretion was evident for 1500 feet to the east of the harbor. Mild erosion persisted to the east of this section as well as directly west of the harbor entrance. The post-breakwater period (1973-1978) has seen a marked increase in the accretion in the area directly east and west of the piers. The reach to the east of a point 1300 feet east of the piers has seen annual erosion rates that are somewhat greater than those that existed prior to the breakwater construction. The recent trend (1974-1978) over the eastern half of Linwood Beach, however, has been one of mild accretion.

To the west of the harbor, the pre-breakwater period saw erosion directly to the west of the west harbor pier with accretion to a distance of 600 feet beyond. This pattern has been reversed since the construction of the breakwater due both to the sand impoundment capability of the harbor structures and to the mechanical sand bypassing operation that was performed in 1975.

Based on the analyses of historical bathymetric charts, the following conclusions have been made concerning the nature and extent of lakebed elevation changes adjacent to Vermilion Harbor:

1) In 1877, the lakebed to the west of Vermilion Harbor had a thin, discontinuous sand cover. Broken rock and cobbles were exposed over much of the area. To the east of the harbor, a near continuous surficial sand cover existed in 1877.

2) Bathymetric comparison between charts of 1877 and 1961 show very large expanses within the study region where no significant bathymetric change has occurred. There were a few, isolated sections of sediment accumulation of as much as five feet. Only one, minor erosional area was detected.

3) Examination of charts from the past 40 years shows that the recent changes of lakebed elevation to the west of the harbor have been insignificant. It is presumed, therefore, that the majority of the bathymetric change that has been documented between 1877 and 1961 occurred prior to 1935.

4) Data show that the present condition of the offshore lakebed both east and west of Vermilion is one of isolated, thin patches of sediment overlaying a near-continuous base of rock and cobbles. This leads to the belief that the present offshore zone cannot be eroded to any great extent and that this zone holds insignificant volumes of sedimentary material that would serve to naturally replenish the beaches of the region.

5) Based on data assembled by Stanley Consultants (1978), the recent trends of erosion and accretion of the nearshore profile have fluctuated in response to both the high lake levels of the early 1970's and to the construction of the offshore breakwater in 1973. The most recent trend shows shoreline stabilization with mild profile accretion adjacent to the harbor piers and on the easterly half of Linwood Beach. A central portion of Linwood Beach is experiencing mild erosion of the adjacent nearshore profile.

6) Due to the lack of appropriate survey data, a similar analysis cannot be conducted to the west of a point located 1000 feet west of Vermilion harbor. In general, it is believed that the profile west of the harbor is relatively bare of sediment and major changes of profile elevation are not expected.

3.4 HISTORICAL SHORELINE COMPARISON, 1837-1935

Efforts to develop the city of Vermilion as a major port of commerce on Lake Erie began in the 1830's. During that decade, the Federal

Government authorized construction of the harbor piers to provide improved navigation at the port. The erosive forces of Lake Erie became a major concern of lakeshore developers at that time. The documented history of Vermilion underscores this fact.

> "During the decades of the 1840's and '50's .....
> ... the center of town gradually was leaving its old boundaries along the west bank of the Vermilion River and was creeping south towards Liberty Street. One reason for the shift in the limits of the town was the availability of land. Another reason was the gradual encroachment of Lake Erie upon the town. When the first settlers came to the banks of the Vermilion River, they found a wide sand beach extending from the mouth of the river west along the entire length of the township. This beach soon began to give way to the action of the waves of Lake Erie. Within five decades, many acres of land had been swallowed up by the surging billows of the lake. When Horatio Perry built his brick house in 1821, he placed it twenty rods back from the lake road, but because of constant erosion it had washed into the lake by the late 1850's. Captain William Austin's house and the old log schoolhouse located at the end of Main Street shared a like fate.
>
> By 1860, many of the lots along the lake nearly were overrun by water. A number of the local residents believed that the building of the Black Rock Dam, in 1826, as a feeder for the New York and Erie Canal, was responsible for the rise in the level of the lake. They tried to stop the advance of the lake by building barricades and hoped that the two parallel piers at the mouth of the river would solve the problem by reducing the momentum of the waves. All their efforts were to no avail.
>
> Thomas A. Smith
> Qulanie Thepy:
> The Golden Age of
> Harbourtown
> Vermilion, 1837-1879

Figure 3.4.1 shows historical shorelines adjacent to Vermilion Harbor. Immediately following the completion of the harbor piers in 1839, a dramatic readjustment of the shoreline took place. Comparison of the 1837 shoreline with that of 1848 shows that this period saw the

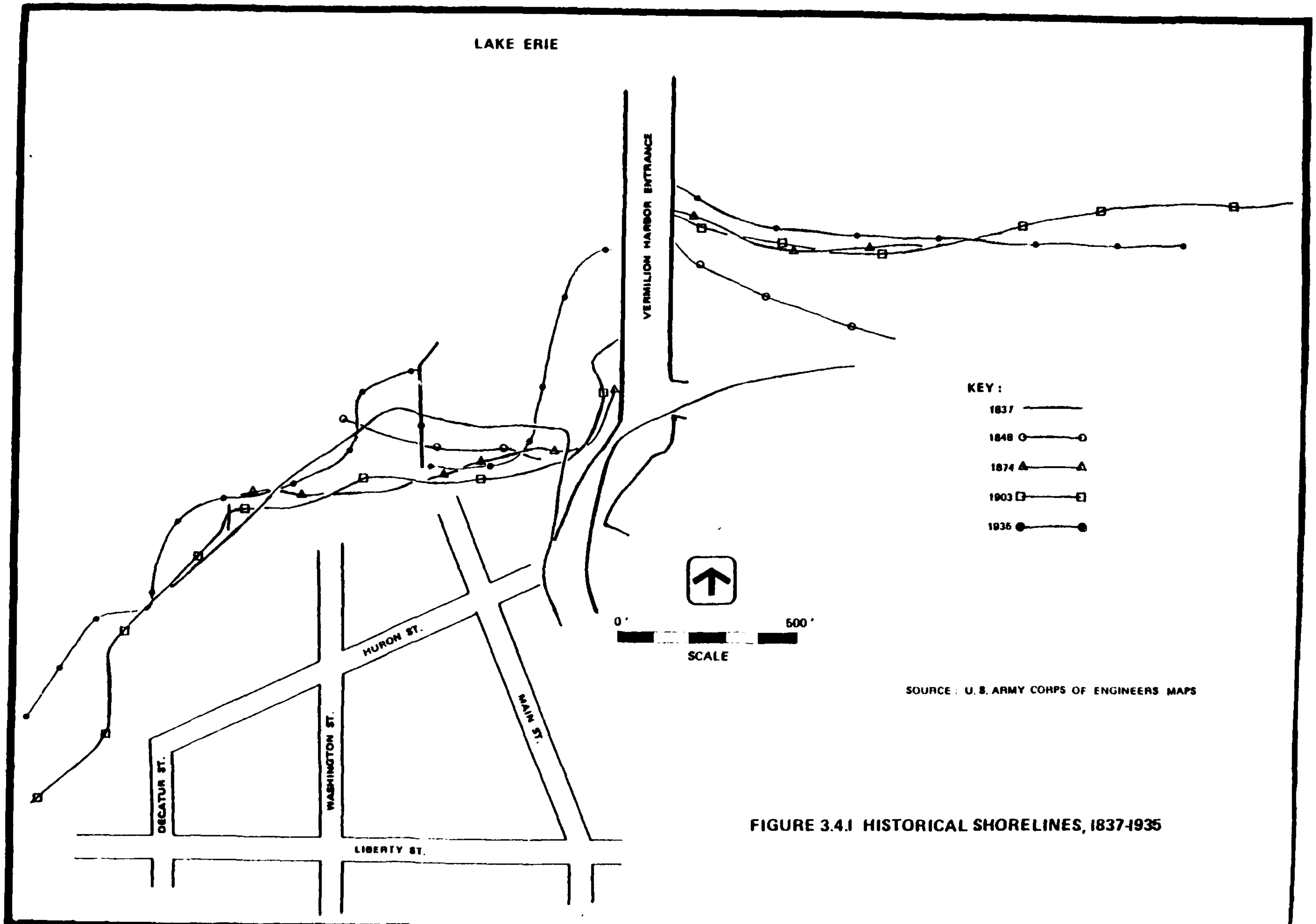


FIGURE 3.4.1 HISTORICAL SHORELINES, 1837-1935

beach width to the east increase by 500 feet, while the beach to the west eroded a distance of 100 feet. Maps of the mid-1800's show that the bluff and shore stabilized in roughly these positions in less than 10 years following pier construction. Because the property to the west of the harbor was an important section of the new, thriving community, steps were taken at that time to halt the shore erosion in that area. The rate of shoreline loss decreased as shore protection measures were implemented and the data from later years shows that gradual fluctuation about a mean beach position became the predominant trend.

Figure 3.4.2 presents shoreline change rates to the west of Vermilion Harbor for various periods prior to 1935. As mentioned above, immediate erosion following the pier construction of 1839 is apparent. Subsequent to that period, however, accretion tends to dominate at various times. The long-term trend between 1837 and 1935 in this area is one of erosion at 1 to 2 feet/year.

3.5 HISTORICAL BLUFFLINE COMPARISON, 1877-1973

The Ohio Department of Natural Resources has compiled a comparison of the blufflines adjacent to Vermilion, Ohio, between 1877 and 1973. The results of this comparison are presented as average erosion rates over the 96-year period in Figure 3.5.1. This plot clearly shows that bluff erosion has increased as one proceeds to the west from Vermilion. The average long-term rates of bluff recession approach a maximum of 2 feet/year at Sherod Park. Due to the early development of the city of Vermilion and the resultant protection that the City's bluff received, bluff loss in the City was negligible during this study period.

In order to determine the contribution of littoral sediments from the bluff, an analysis was undertaken as follows:

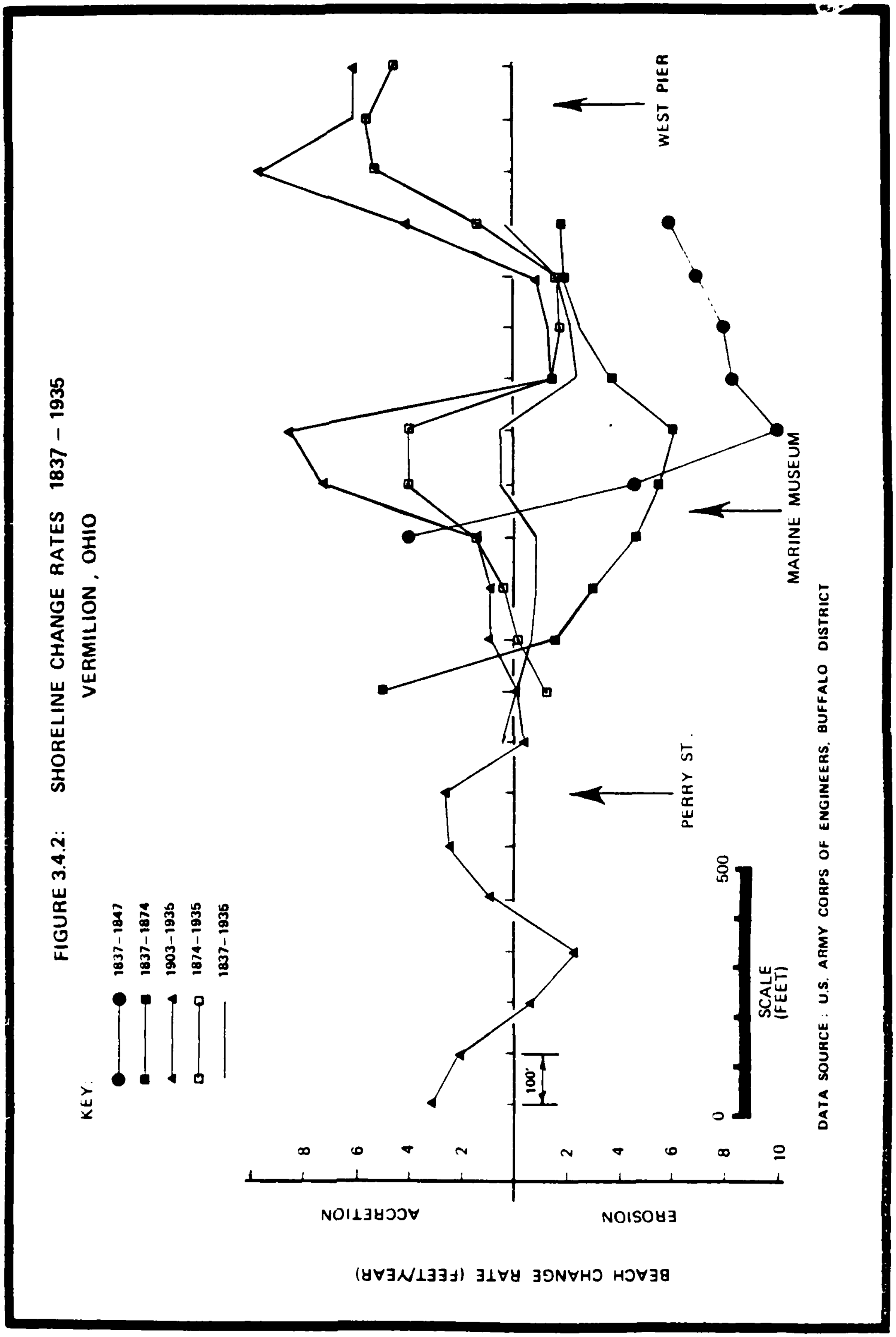
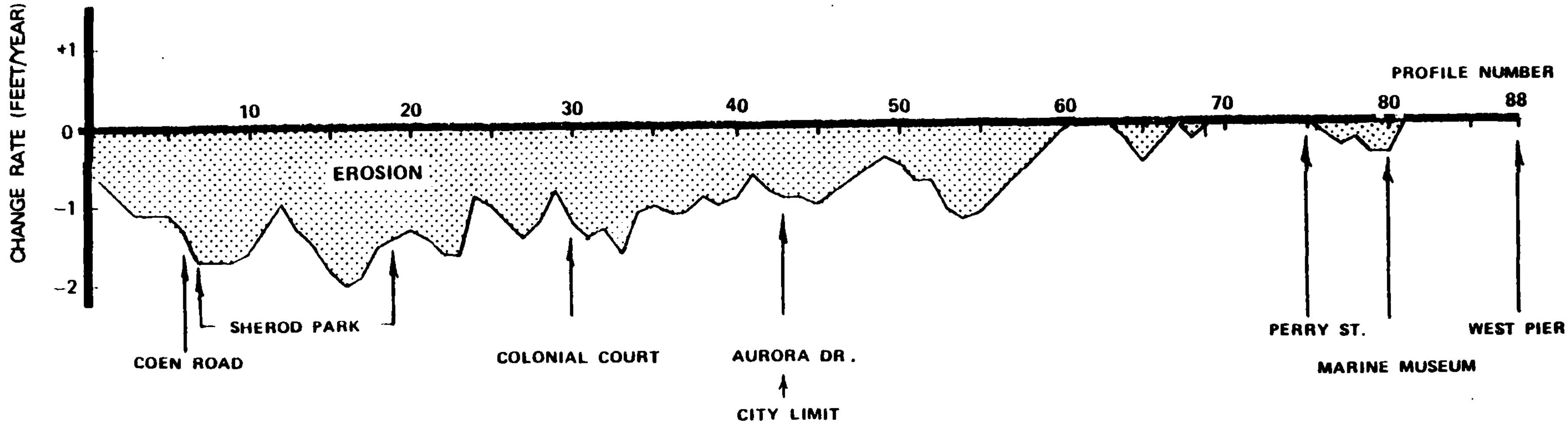


FIGURE 3.4.2: SHORELINE CHANGE RATES 1837 – 1935
VERMILION, OHIO

FIGURE 3.5.1. BLUFF RECESSION, 1877–1973
VERMILION, OHIO



DATA SOURCE: OHIO DEPARTMENT OF NATURAL RESOURCES

1) Bluff recession at 100 foot profile increments was measured for the 1877-1973 period.

2) The present bluff height was determined.

3) Assuming a sand content of 15%, the total volume of beach material contributed from the bluff to the beach and littoral zone was estimated.

The results of this procedure are superimposed on the basemap in Figure 3.5.2. Again, it is clear that the majority of beach sediments contributed from the bluff originated at locations to the west of Vermilion where few coastal protection structures existed prior to the 1920's.

3.6 AERIAL PHOTOGRAPH ANALYSIS, 1937-1979

In order to quantify short-term as well as long-term shoreline changes in addition to extending the existing historical data to the most recent point of time, sequences of aerial photographs taken between 1937 and 1979 were used to determine successive shoreline positions. Nine series of photos covering the years 1937, 1949, 1958, 1964, 1971, 1977, 1978, 1979 (spring), and 1979 (fall) were analyzed.

A summary of the aerial photographs used in the analysis of recent shoreline positions is presented in Table 3, along with the lake levels which existed at the time of photography. The selected air photos have an average interval of approximately six years, permitting short-term fluctuations in shoreline positions and erosion rates to be distinguished.

The air photo digitization process may be summarized as follows:

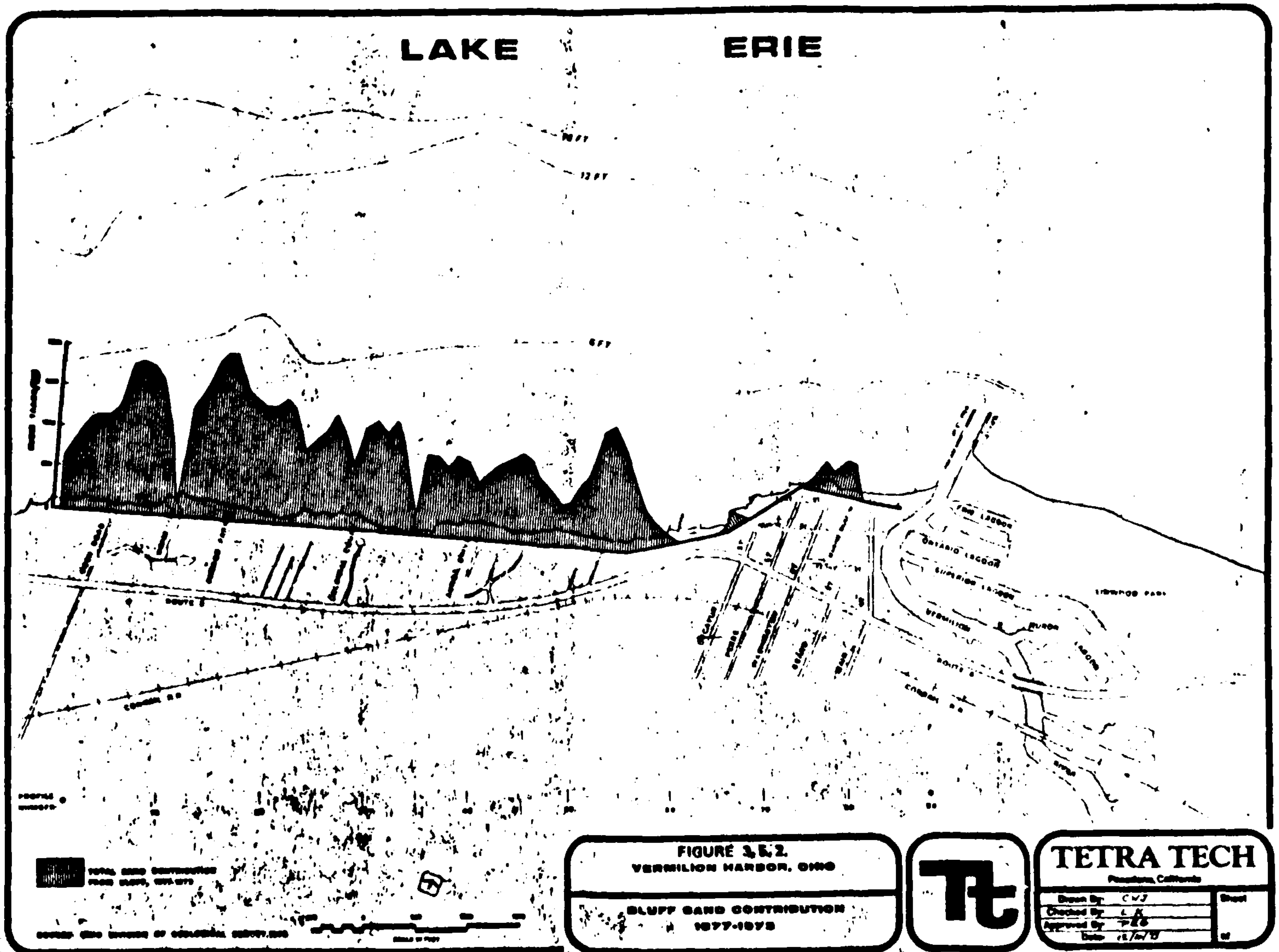


FIGURE 3.5.2
VERMILION HARBOR, OHIO

BLUFF SAND CONTRIBUTION
1877-1973

3-20

1. For each photograph to be analyzed, a number of permanent ground targets found also in a selected "base year" photograph (generally near the midpoint of the period under analysis) are identified and catalogued. The shoreline is penciled in at the land-water interface.

2. Each photo is placed on a large electronic digitizer board and its pre-selected targets and shoreline are digitized relative to an arbitrary digitizer board coordinate system. Nominal accuracy of the board is one thousandth of an inch, producing a possible error of about 0.4 feet for a 1" = 400' scale photo.

3. The relative position of each target is corrected for the effect of parallax, which depends upon camera height, target elevation (estimated from ground survey and U.S. Geological Survey Quadrangle Sheets), and target location in the photo frame (determined automatically by the computer).

4. All photos are adjusted to the scale of the selected base year using least-mean-square checks on the target network. A universal coordinate system is then imposed which permits comparison of successive shoreline positions.

5. Following selection of a baseline which parallels the coast under scrutiny, relative shoreline positions are determined as the perpendicular distance from this line.

6. Measured shoreline positions are corrected for changes in lake levels as dictated by prevailing beach slopes.

Table 3: Air Photo and Lake Level Summary

YEAR	MONTH	APPROXIMATE PHOTO SCALE	PHOTO LAKE LEVEL (IGLD)	DIFFERENCE FROM LWD (568.6' IGLD)	DIFFERENCE FROM 117-YEAR MEAN LAKE LEVEL (570.4' IGLD)
1937	1[illegible]	1" = 400'	569.0	0.4	-1.4
1949	5	1" = 400'	570.8	2.2	+0.4
1958	7	1" = 400'	570.1	1.5	-0.3
1964	5	1" = 400'	569.7	1.1	-0.7
1971	5	1" = 400'	571.7	3.1	+1.3
1977	3	1" = 400'	570.6	2.0	+0.2
1978	4	1" = 400'	572.3	3.7	+1.9
1979	4	1" = 400'	571.6	3.0	+1.2
1979	9	1" = 400'	572.0	3.4	+1.6

The distribution of shoreline stations (hereafter referred to as "Profiles") for the present study is shown on the base map, Figure 3.6.1. Consecutive profiles are separated by 100 foot intervals.

For each photo, computations are undertaken to determine the distance that the shoreline lies from the baseline as measured along each profile. In this way, shoreline position for any photo and shoreline rates of change (accretion or erosion) between any two photo years can be determined.

3.6.1 RECENT TRENDS

Along the study reach, the shoreline position has fluctuated in response to various natural and man-induced factors over the 42-year

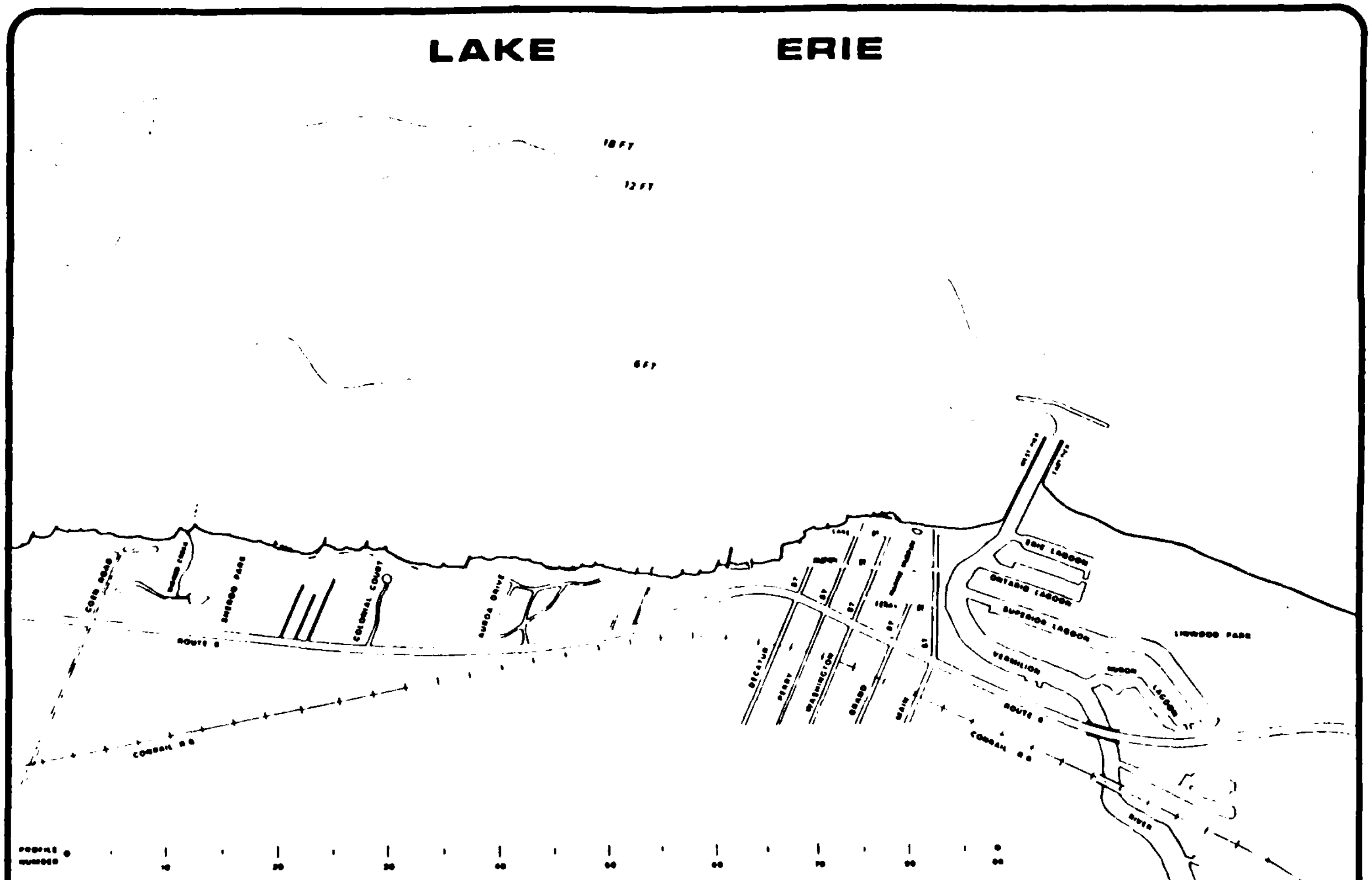


FIGURE 3B1.
VERMILION HARBOR, OHIO

BASE MAP

TETRA TECH
Pasadena, California

photo period. Figure 3.6.1.1 shows the position of the 1979 shoreline relative to the "maximum" (most lakeward) and "minimum" (most shoreward) shorelines that were measured from the photos dating from 1937. Along the Sherod Park shore, the 1979 beach lies at the most shoreward position measured in any photo. The same condition exists in front of the Marine Museum in Vermilion. This is indicative of an area undergoing active erosion. Conversely, the reach contained within profiles 50 and 70 are very close to the most lakeward position that they have achieved in 42 years. This indicates a trend towards shoreline growth. Other areas show that they are currently midway between the lakeward and landward extremes of the photo study period.

The list of aerial photos that were available from the Buffalo District for the shoreline change analysis did not include the years immediately preceding or following 1973---the year that the offshore breakwater was constructed. Thus, the photos of 1971 and 1978-1979 must be scrutinized in order to define the shoreline changes that can be attributed to the breakwater.

A comparison of long-term average rates of shoreline change have been used to evaluate the current level of shoreline stability west of Vermilion. The shoreline positions for 1949, 1971, and 1979 have been reduced to shoreline change rates from 1949-1971 and 1949-1979 in the belief that the residual will serve as an indication of the changes caused by the offshore breakwater. Figure 3.6.1.2 shows the shoreline rates for the two periods 1949-1971 and 1949-1979 for each profile along the study reach. The extremes for these two periods are erosion at -1.7 feet/year at Sherod Park and accretion at +2.1 feet/year about 1200 feet east of Aurora Drive.

The residual, or difference in rate between these two periods, is plotted directly below the shoreline change graph. This serves to indicate the change in the long-term trend of shoreline change that took place during the 1971-1979 period. The results of this analysis show that alternating trends of erosion and accretion have developed since 1971 along the study

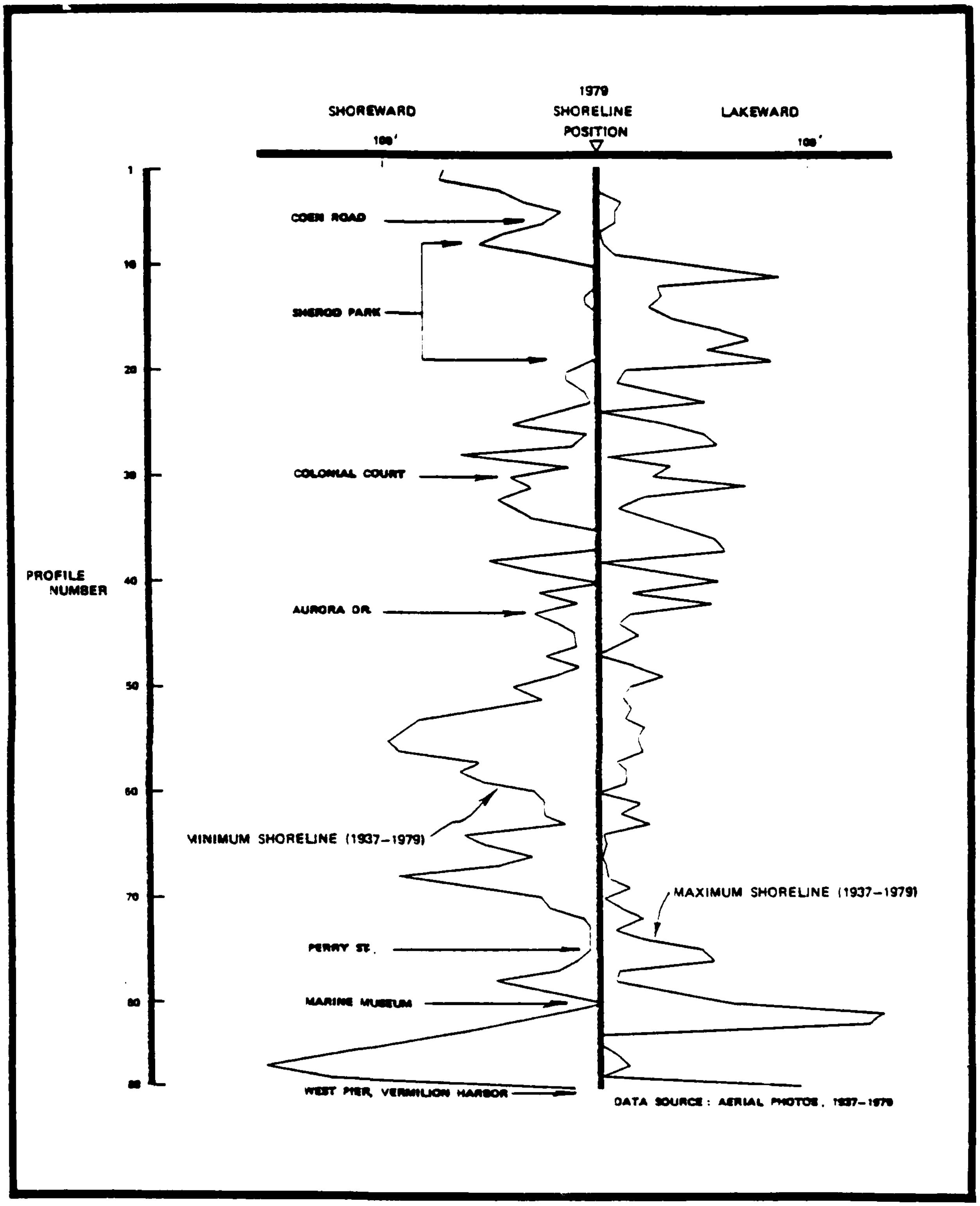
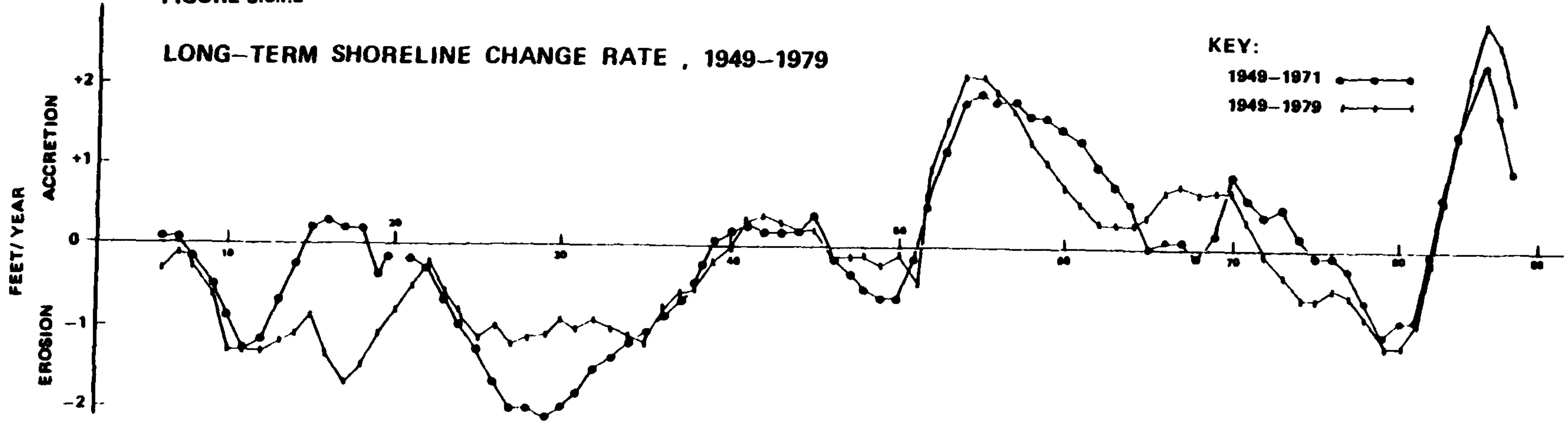


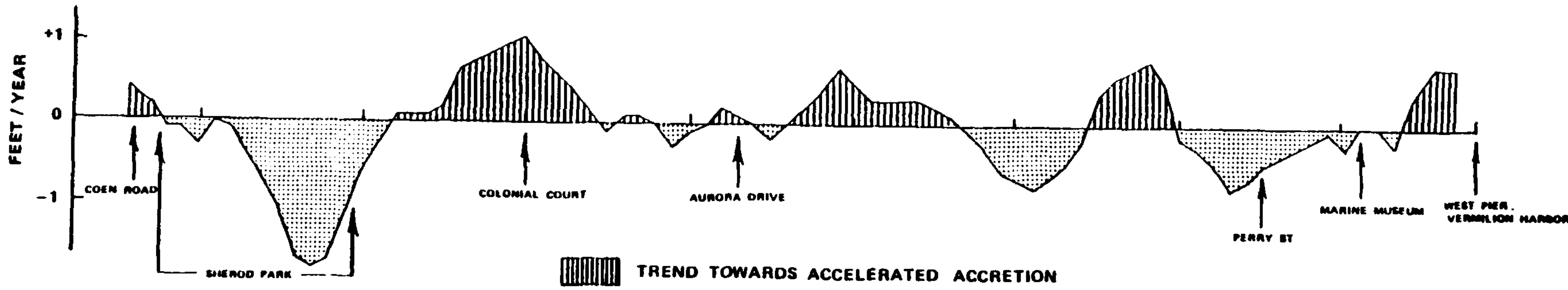
FIGURE 3.6.I.J POSITION OF 1979 SHORELINE RELATIVE TO HISTORICAL SHORES

FIGURE 3.6.1.2

LONG–TERM SHORELINE CHANGE RATE, 1949–1979



DEVIATION FROM LONG–TERM SHORELINE CHANGE RATE, 1971–1979



DATA SOURCE: AERIAL PHOTOS, 1949–1979

reach. The decade of the 1970's exhibited the highest lake levels of the 165 year record. The influence of the high lake levels led to dramatic shore erosion along much of the Great Lakes shoreline. The most severe erosion along the study reach during this period occurred at Sherod Park with similar, yet less dramatic, beach loss at profile 60 (1500' west of Perry St.) and also along the City shoreline between the Marine Museum and Decatur Street. The trend toward shoreline growth occurred during the 1971-1979 period at Colonial Court with minor accretion also to the west of Aurora Drive, between Jefferson Street and Decatur Street, and immediately west of the west harbor pier.

Several major points are suggested by the shoreline change data:

1) Areas of net accretion are generally associated with sediment accumulation up-drift of littoral barriers (groins, concrete piers). This is especially evident between profiles 55 and 70. Downdrift of such structures, however, the shoreline is subject to sediment starvation and subsequent erosion. If structural protection is not extended to the downdrift shore, localized erosion may develop.

2) In areas where shoreline fortification is intermittent rather than continuous, erosion typically increases downdrift of the fortified sector.

3) In the study area, offshore sand deposits have been depleted to such an extent that longshore sand bars are non-existant.

   Consequently, it appears that the bulk of the littoral drift is concentrated over a narrow strip of sand close to shore rather than being distributed over a wide surf zone between the shore and an offshore breaker line. Under this condition, any small protrusion extending into the lake (groin, jetty, pier) will act as an effective littoral barrier.

4.0 EVALUATION OF SHORELINE RESPONSE TO HARBOR STRUCTURES

4.1 SHORELINE CONDITION 1: NO FEDERAL HARBOR ENTRANCE STRUCTURES (Assuming no shore protection works)

In order to determine the influence that the original harbor piers have had on the shoreline to the west of Vermilion, an estimate must be made of the position of the shoreline prior to the construction of the piers in 1836-39. An 1837 map delineates the shoreline immediately adjacent to the harbor. Much of the city street grid has not changed since 1837 thereby facilitating the shoreline comparison. Unfortunately, a map of the Vermilion shoreline of 1837 for the area to the west of Decatur Street could not be found. Therefore, the 1837 shoreline for this reach had to be estimated based on the following assumptions:

1) The long-term bluff erosion rate established at each profile (using Ohio Department of Natural Resources Data) for the period 1877-1973 can be applied to the 1837-1877 period. Lakeward advancement of the 1973 bluffline at each profile by a distance equal to the long-term erosion rate multiplied by 136 years (= 1973-1837) yields the 1837 bluffline. (A tabulation of the Ohio Dept. of Natural Resources Bluff Erosion rate at each profile is presented in Appendix A).

2) Once the 1837 shoreline has been determined at each profile based on long-term bluff erosion records, the 1973 shoreline can be derived for the "no pier-no protective structure" condition by advancing shoreward a distance equal to the product of the "natural erosion rate" of -1.0 feet/year (based on the long-term bluff erosion measured in unprotected reaches of Lake Erie's southern shore) and the time interval (136 years). The use of the "natural erosion rate" assumes that virtually no shoreline fortification would have been built in the study area if the piers were not constructed. This is due to the belief that

Vermilion's early commercial success and prosperity were based on its busy harbor facilities. Without such facilities, Vermilion's status as a lakeport would have been diminished. If this were the case, the cost of protecting the city's shoreline could have been prohibitive relative to the resources available within the community for such improvements. The estimated 1837 bluff and shoreline are plotted on the maps of the actual 1973 shoreline presented in Figures 4.1.1A, B, C and D. An 1837 beach width of 100 feet at (LWD) is assumed. Further, the expected bluff for 1973 and 2023 A.D. are plotted for the "no piers-no protective structure" condition.

The expected shorelines for 1973 and 2023 A.D. for Condition No.1 are not presented in the figures to promote clarity. The beach width for these two years is assumed to be 50 feet (at LWD) based on an average 20 foot width at mean lake level (+2 LWD) and a 1:15 nearshore slope.

Some general comments concerning the comparison of the 1973 shore position for Condition No. 1 ("no piers-no structures") and the actual position (as indicated by aerial photos) are in order.

1) In unprotected areas of the study reach (Sherod Park, for example) the shoreline has eroded to a greater degree than if the harbor piers and attendant protection works had never been built. This is due to the resultant sediment blockage by the harbor piers and the reduction of bluff erosion resulting from shoreline fortification along the reach.

2) From Aurora Drive to the east, the shoreline is further lakeward than if the natural, "unprotected" condition had prevailed since 1837. This is due to the decrease in bluff erosion rate caused by shoreline fortification along this section of shore.

3) To the east of Vermilion Harbor, a large fillet extends 3,000 feet from the east pier. This acreage was created by the pier-induced blockage of westerly flowing littoral drift that began

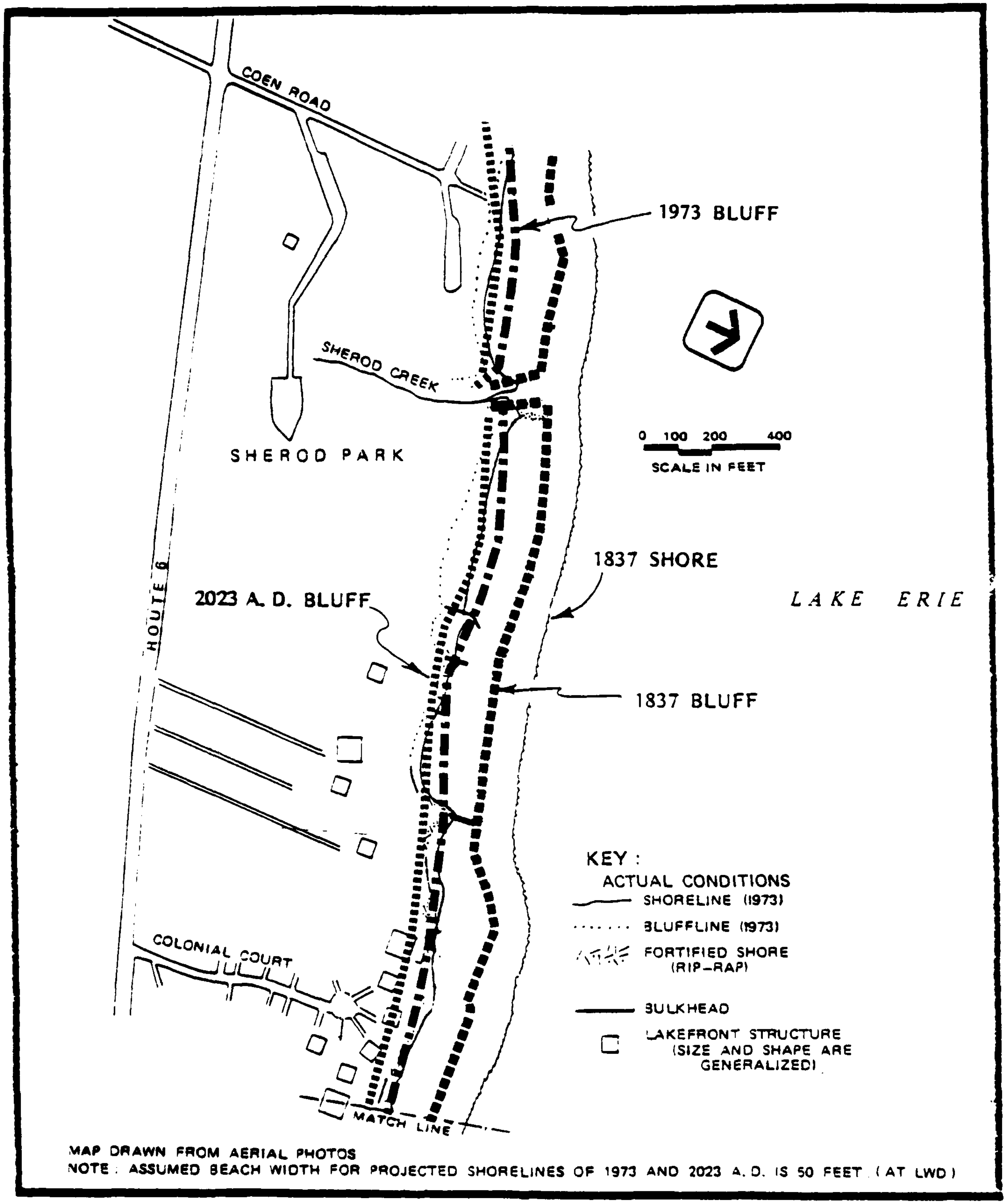


FIGURE 4.1.1 A: HISTORICAL AND PREDICTED SHORELINES – 1837, 1973, 2023 A.D.
SHORELINE CONDITION NO. I: NO FEDERAL ENTRANCES STRUCTURES OR PRIVATE SHORE PROTECTION WORKS

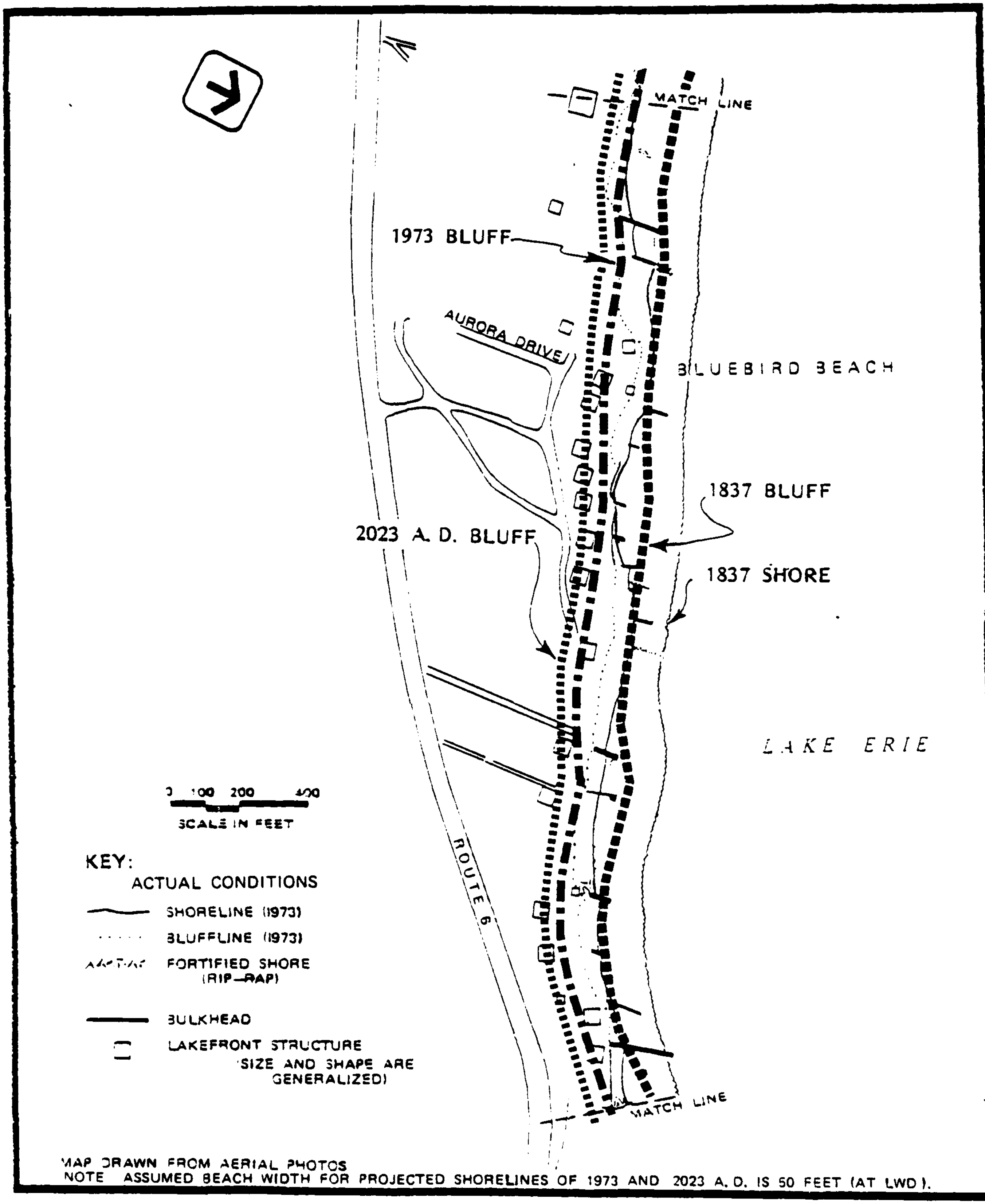


FIGURE 4.1J B: HISTORICAL AND PREDICTED SHORELINES, SHORELINE CONDITION NO. I

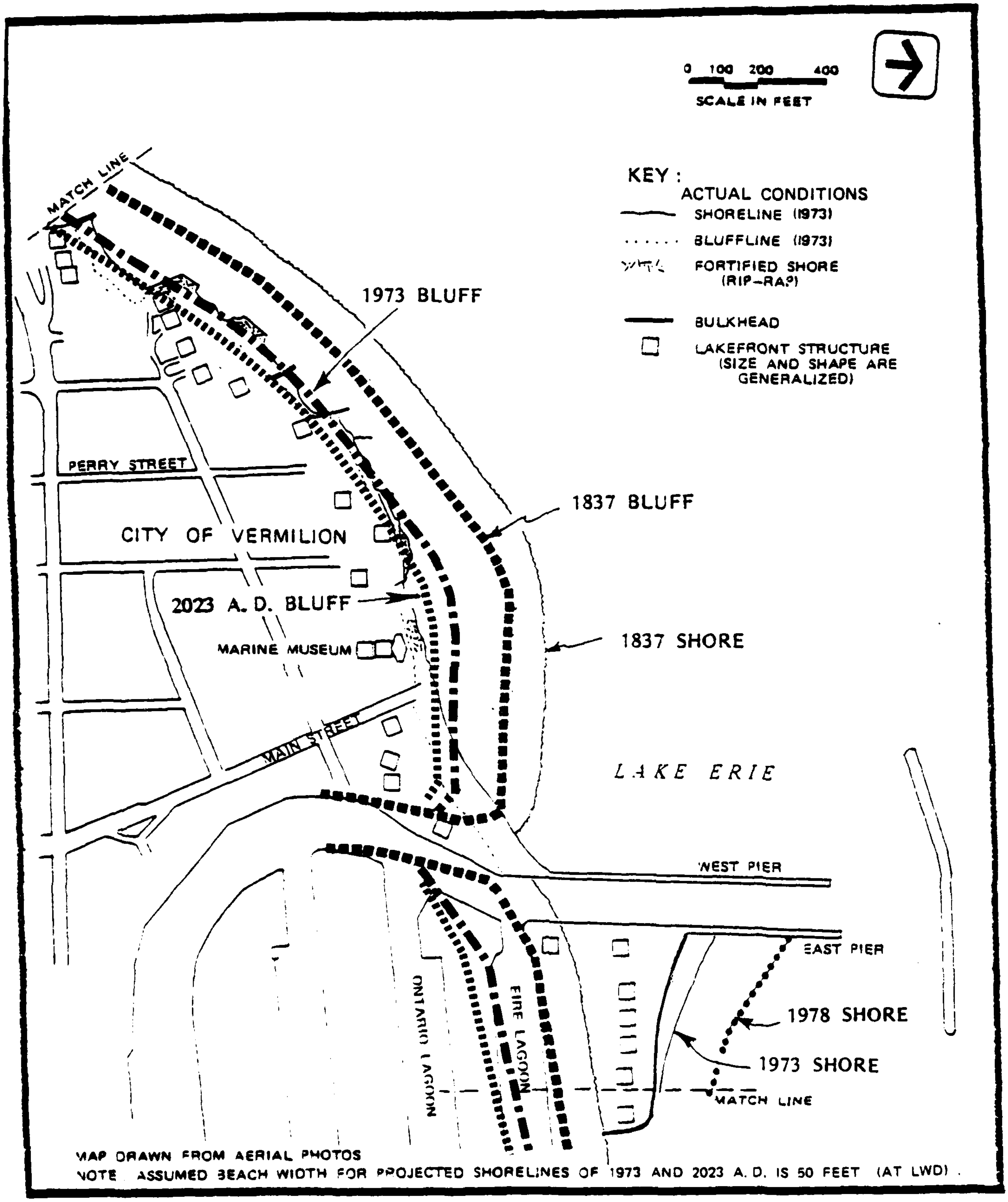


FIGURE 4.1.1 C: HISTORICAL AND PREDICTED SHORELINES, SHORELINE CONDITION NO. 1

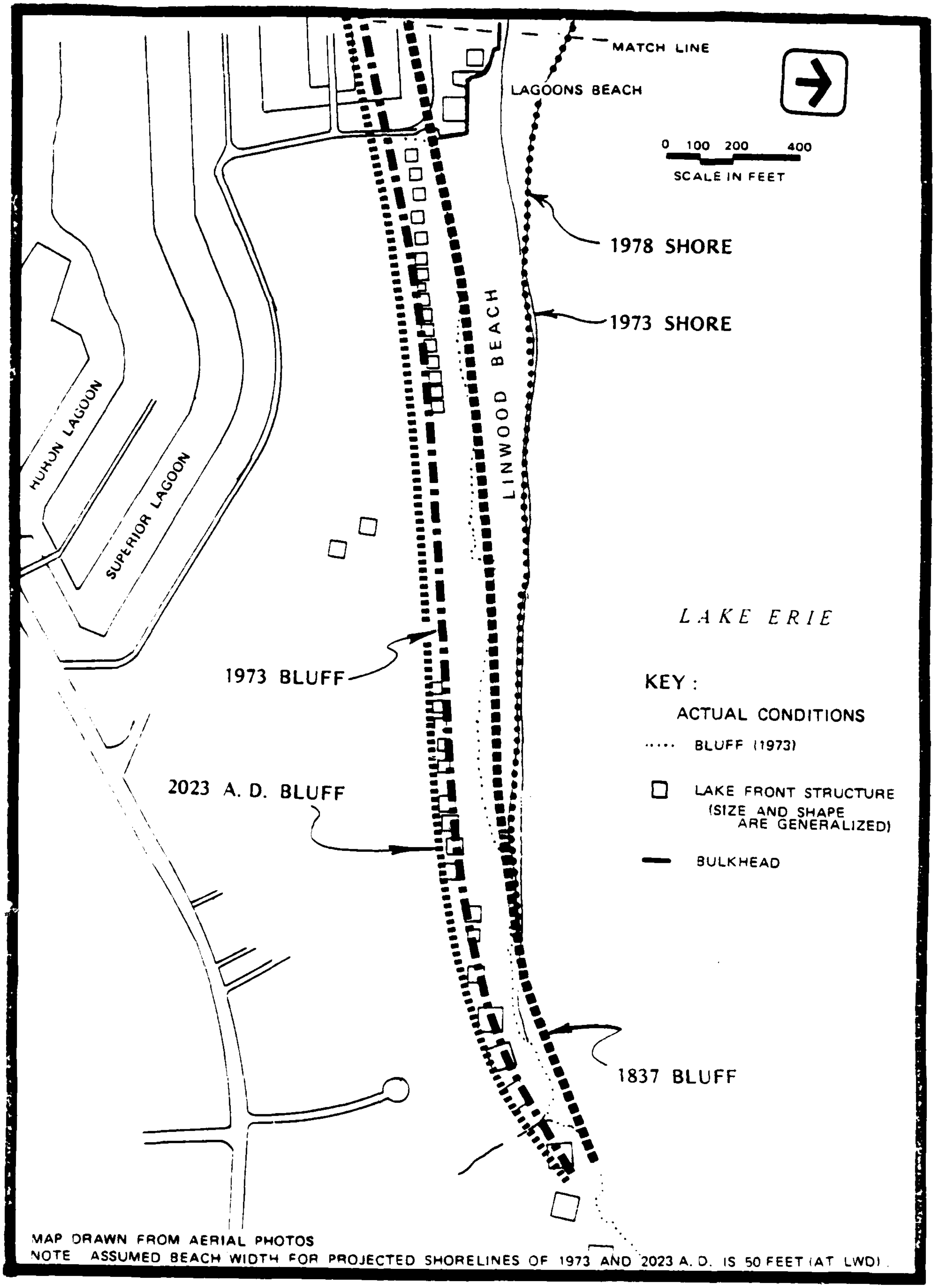


FIGURE 4.1.1.D : HISTORICAL AND PREDICTED SHORELINES, SHORELINE CONDITION NO. 1

following the pier construction of 1837-39. The area of land contained within this accretional zone is approximately 20 acres.

4.2 SHORELINE CONDITION 2: FEDERAL PROJECT WITH HARBOR PIERS ONLY (Assuming existence of private shore protection works)

The 1837 bluff and shoreline positions were determined using the methods specified in Section 4.1. These lines are superimposed upon the actual 1973 shoreline in Figures 4.2.1A, B and C. The long-term bluff erosion data (from the Ohio Department of Natural Resources) and the shoreline change data (from air photo analysis) were combined to yield the predicted 2023 A.D. bluff positions noted in these figures.

Again, a 50-foot wide beach is assumed for the 2023 A.D. shoreline based on the existence of a 20-foot wide beach at mean lake level (+2 LWD) and a 1:15 nearshore slope. Analyses of recent shoreline changes show accretion caused by the sheltering effect of the harbor structures along a 300 foot reach of private property immediately west of the harbor. This shoreline is expected to exceed the average beach width of 50 feet (specified as the average value for the beaches further to the west in the year 2023 A.D). Currently, no public benefit is gained from the accretional trend in this area.

It can be seen that the prediction shows that the major areas of recession will be located to the west of Aurora Drive along this relatively unprotected reach of shore. The areas nearer to the city of Vermilion are expected to remain more stable due to the structural protection that currently exists along this reach. No change in the bluff position is expected to 2023 A.D. throughout most of the Vermilion shoreline bounded by Decatur Street and the harbor. Because the photo analysis was not performed for the shore to the east of the harbor piers, no quantitative prediction can be offered for the position or extent of Linwood and Lagoons Beaches in 2023 A.D.

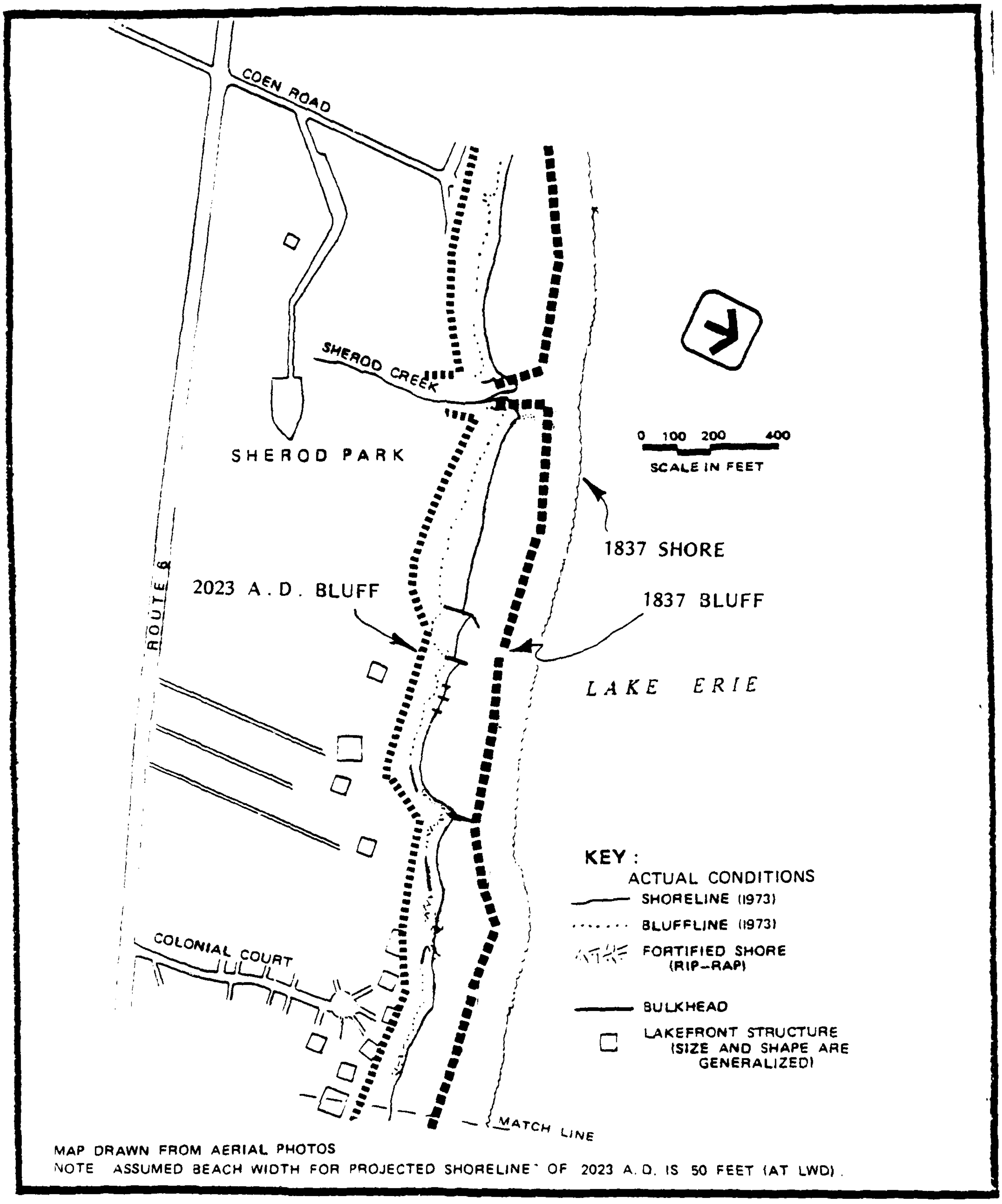


FIGURE 4.2.1 A: HISTORICAL AND PREDICTED SHORELINE – 1837, 1973, 2023 A. D. SHORELINE CONDITION NO. 2: HARBOR PIERS ONLY AND ATTENDENT SHORE PROTECTION WORKS

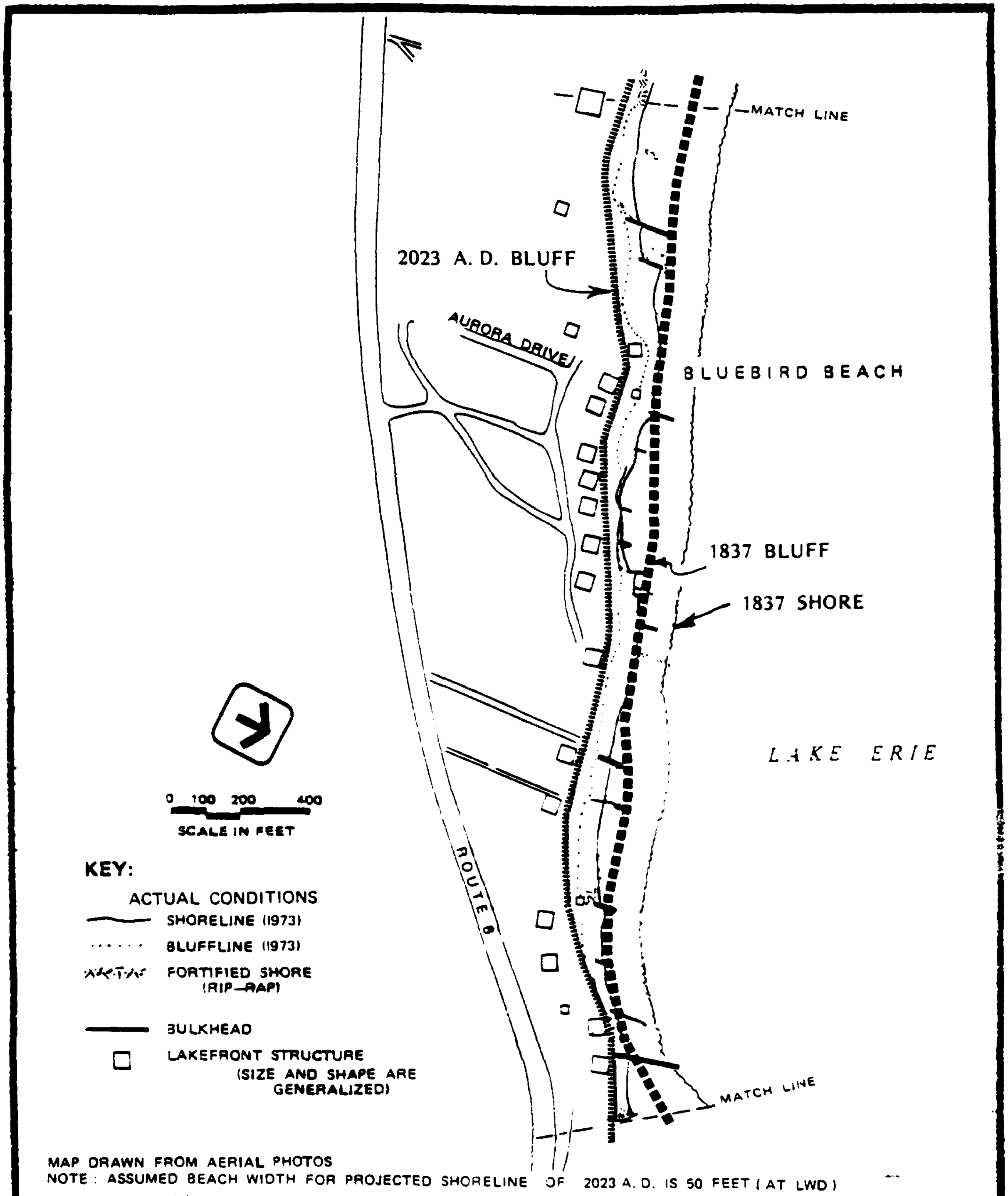


FIGURE 4.2J B HISTORICAL AND PREDICTED SHORELINES, SHORELINE CONDITION NO. 2

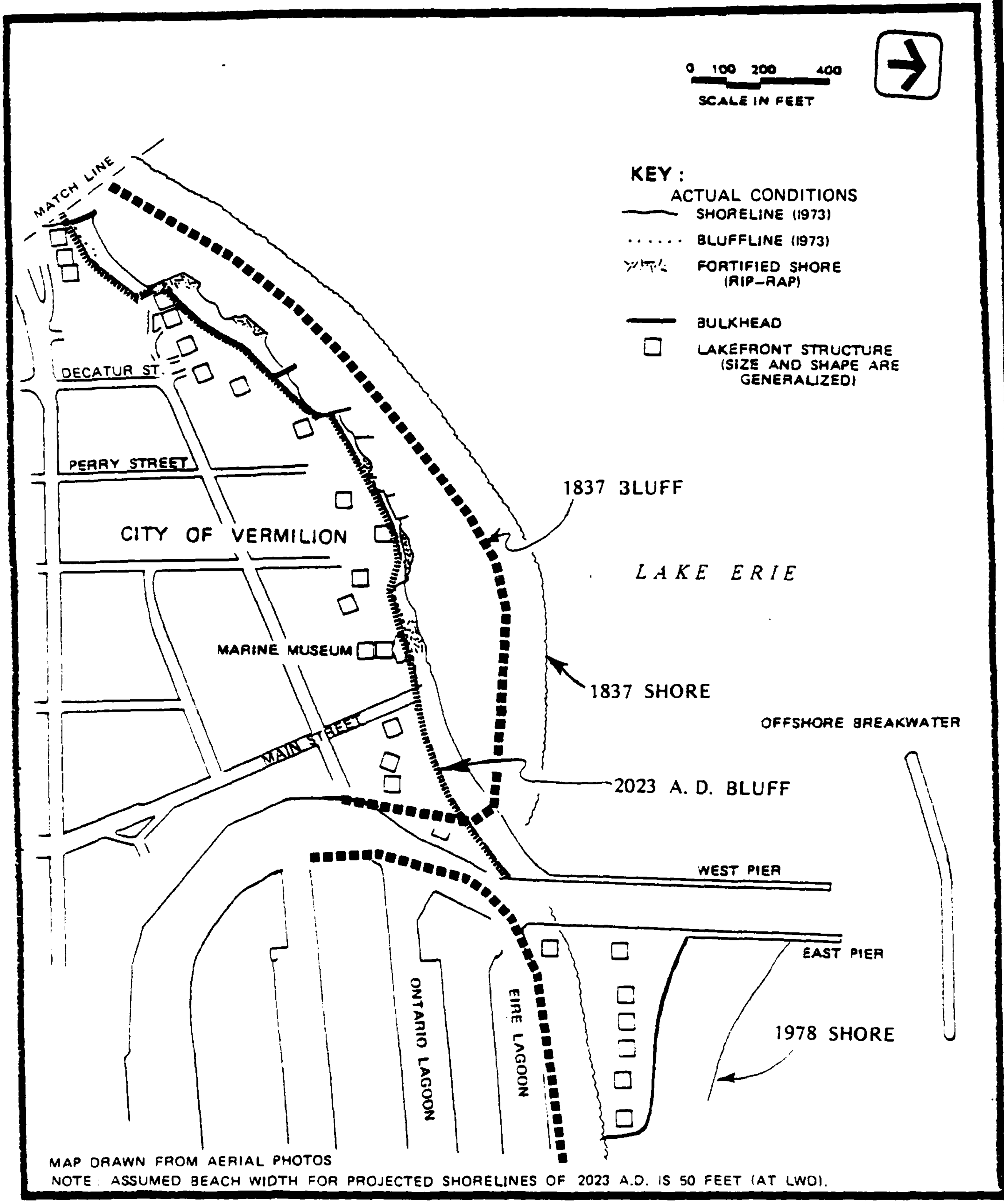


FIGURE 4.2.1 C HISTORICAL AND PREDICTED SHORELINES, SHORELINE CONDITION NO. 2

4.3 SHORELINE CONDITION 3: EXISTING FEDERAL PROJECT (PIERS AND BREAKWATER)

The major impacts that the breakwater construction of 1973 has on the shoreline to the west of Vermilion Harbor are:

1) The naturally bypassed sediment volume flowing to the west around the harbor has decreased due to impoundment by the breakwater. Data prepared by Stanley Consultants (1978) shows that this bypassed volume has decreased from 3,400 cubic yards annually to about 1,000 cubic yards.

   It is presumed that material currently bypassing the harbor passes to the north of the offshore breakwater and does not significantly nourish the shore to the west of the harbor. The net downdrift loss of 2,400 cubic yards per year was computed from bathymetric chart comparison. It is evident in the Stanley Consultants analysis that wide variability exists in the volume of natural bypassing (as seen in Figure 3.3.5). The 2,400 cubic yard/year figure is considered a long-term average loss to the down-drift shore caused by the impoundment capability of the offshore breakwater.

2) The breakwater creates a portective wave shadow on the shore immediately to the west. During periods of northeast storms, wave attenuation along the Vermilion City Beach down to Main Street should supply increased shore protection relative to the pre-breakwater condition.

The loss of the small volume of naturally bypassed sediment caused by the offshore breakwater is not judged to induce a major change in future shore or bluff position. The shore erosion information gained from the air photo analysis (Section 3.6.1) shows that no wide-spread comprehensive erosion to the west of the harbor can be attributed directly to the breakwater. The effect on the downdrift shore caused by the loss of material impounded by the offshore breakwater (on the order of 2,400 c.y./year), is undoubtably "masked" by the fortified nature of the shoreline to the west of the harbor. Lakefront properities currently experiencing a deficiency of littoral supply are not experiencing shore erosion due to the existence of privately-constructed shore protection works.

Based on these considerations, the predicted shore and bluff positions for 2023 A.D. are unchanged from those derived from the analysis of the "no breakwater" condition (Condition No. 2, Section 4.2). Therefore, the position of the 2023 A.D. bluff for Condition No. 3 is presented in Figure 4.2.1 A-C.

It has been stated previously that the shoreline to the east of the harbor readjusted to a relatively stable position within two to three years of the breakwater construction. Stabilization of the west shore has been masked, however, due to the mechanical bypassing of small quantities of sediment from east to west around the harbor. Due to the lack of adequate survey information, it is impossible to determine the length of time required for the western shoreline to stabilize following breakwater construction, but it is believed that such readjustment took about three years for completion (the extended period caused, in part, by the mechanical bypassing operation).

A comparison of bluffline position for Conditions 1, 2, and 3 is presented in Section 5.

4.4 SEDIMENT BUDGET

The determination of a sediment budget for a reach of coastline is a bookkeeping technique to assess the various input, output, and storage paths that sediment can take within a littoral system. This is particularly useful in establishing a reliable estimate of the quantity of littoral drift.

The principle gains and losses to the littoral system along a reach of coast are as follows:

1) Longshore Sediment Transport (Littoral Drift). Sediment can move into or out of a coastal control volume by this mode of transport.

2) Loss to Lake Bottom Below - 12 Feet (LWD). Sediment is assumed to be irretrievably lost to the lake floor when it passes below the 12-foot water depth. (CERC Misc. Paper 2-75, 1975).

3) Diversion to Offshore by Structure. A major sediment barrier built on the coast can initially trap sediment and later, once the trapped sedminet has built out to the structure's lakeward extremity, direct it lakeward. If this offshore diversion reaches to depths greater than 12 feet, then the diverted sediment will be lost from the system.

4) Bluff and Shoreline Contribution. If a bluff erodes, the sedimentary material lost from the bluff will be added to the littoral stream. Because the main portion of the bluff in the Vermilion area contains fine-grained sediment, only a small percentage (estimated to be 15%) will contribute to the littoral drift along these shores. While a bluff can only erode, shorelines can erode or accrete. In the case of erosion, the material lost by the beach is gained by the littoral stream. Conversely, beach accretion implies a loss of material from the littoral stream.

5) Profile Contribution. A lake bottom composed of sedimentary material can erode or accrete between the surf zone and the 12 foot contour. Accretion in the profile is seen as a loss from the littoral stream. Likewise, if a profile erodes, a portion of the eroded volume is gained by the littoral stream while the remainder is lost offshore. Thus, the nearshore profile can be considered a site of temporary storage of littoral material. Man-induced losses in the profile caused by dredging must also be considered in this analysis.

The components listed above are illustrated schematically in Figure 4.4.1.

By assessing the various components of the littoral system on a reach by reach basis, an estimate of the littoral drift at any given location can be estimated.

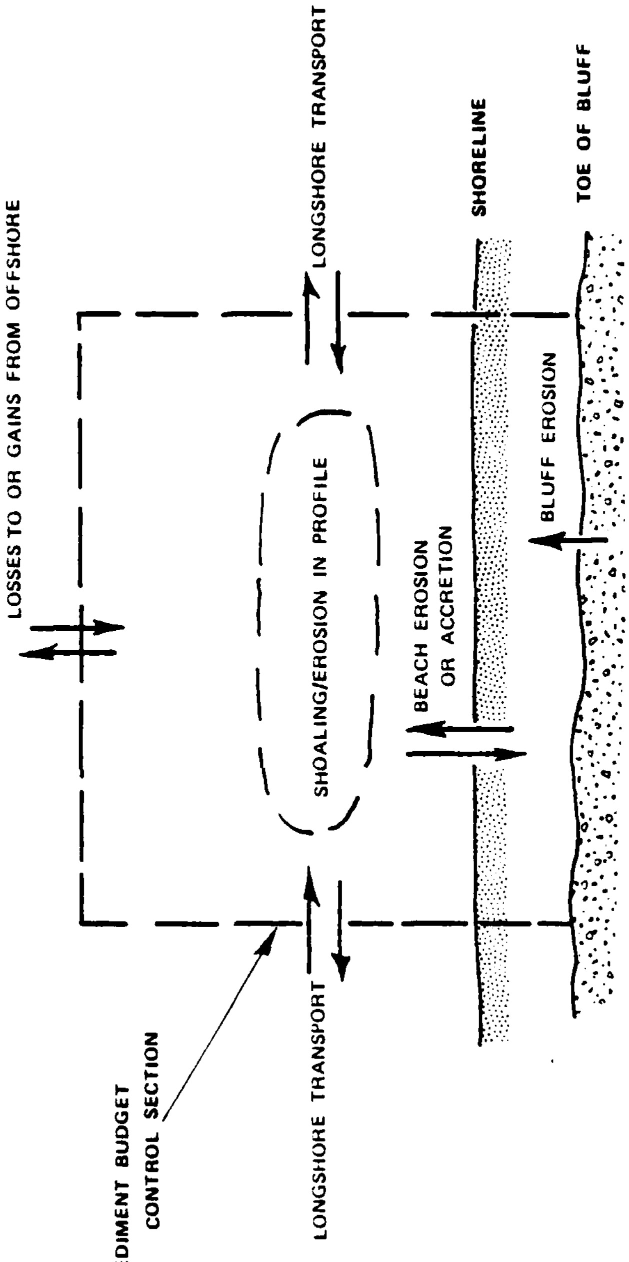


FIGURE 4.4.1 : PROCESSES INFLUENCING SEDIMENT BUDGET

Attempts to accurately develop a sediment budget for the shoreline to the west of Vermilion have been hampered by the total lack of any recent bathymetric survey data along this reach. Thus, one vital component of the sediment budget--the gain or loss of material in the nearshore profile--cannot be computed. Additionally the littoral zone in which sediment flows along this shore is not continuous, being interrupted at various intervals by structures that act to varying degrees as littoral barriers.

The results of the sediment budget analysis presented by Stanley Consultants (Figure 3.3.5) were derived from close scrutiny of precise bathymetric surveys adjacent to Vermilion Harbor. This data shows that the annual average sediment volume that bypasses Vermilion Harbor from the east to the west has decreased from 3,400 C.Y./year to 1,000 C.Y./year since 1973, due primarily to the construction of the offshore breakwater. As stated previously, it is believed that the majority of the volume currently being naturally bypassed travels to the north of the offshore breakwater and does not provide significant nourishment to the downdrift shore. To put these sediment volumes in perspective, the littoral drift quantity that exists to the west of Vermilion Harbor (believed to be on the order of a few thousand cubic yards per year) can be compared to other coastal environments. An open section of ocean coastline may exhibit littoral drift quantities that exceed one million cubic yards/year. On Lake Michigan, coastal areas north of Chicago are now experiencing littoral drift quantities of 100,000 cubic yards/year. By any standard all qualitative and available quantitative data indicate that the magnitude of littoral drift existing in the shore sector west of Vermilion Harbor is exceptionally small and comparable to the range of data collection error of the various surveys that would be used for sediment budget calculation.

Fluctuation of lake level may precipitate fluctuations in drift quantity via shore erosion and accretion. The average annual rate of sediment input from bluff erosion between Coen Road and the harbor has been computed to be only 670 cubic years of sand; the majority of this volume originating

from the bluffs to the west of the city. (Bluff sediment computation contained in Appendix). Again, this value underscores the lack of sediment available for natural beach replenishment. This fact, coupled with the total lack of acceptable bathymetric data in the study reach, yields the conclusion that the computation of a reliable sediment budget is not possible along the lakeshore to the west of Vermilion.

5.0 IMPACT OF HARBOR ENTRANCE STRUCTURES

Based on the bluff and shoreline change analyses conducted in this study, future losses of shorefront acreage can be determined. In the course of this investigation, it was found that certain sections of the study reach have experienced recent trends of accretion as well as erosion. (See Figure 3.6.1.2). The reaches exhibiting shoreline growth since 1973 are associated with the shadow zone created by the recently constructed breakwater and with various other man-made shore protection works that serve as effective impoundment structures. The long-term trend in the unfortified bluffs of the study reach is clearly one of erosion, however, and the quantification of these losses to the year 2023 A.D. must be based on considerations of erosion rates that reflect the long-term trend. In areas of recent fortification efforts, an attempt was made to determine the future performance of these structures in regards to their anticipated effect on the existing long-term trend. The damages associated with shore recession are the following varieties:

1) Loss of recreational usage on the public lands of the study reach. These public lands include the 550-foot long reach containing Vermilion City Beach and the Marine Museum property and the 1300 foot length of Sherod Park.

2) Loss of residential property (both land and structures) that is anticipated by 2023 A.D. if existing long-term erosion trends continue.

3) Loss of property value for properties adjacent to eroding areas but not directly threatened by erosion. This can be translated to a loss of income to state and local governments as property values decrease through the loss or perceived future loss of a limited number of properties of the area.

4) Loss of tax revenue to the Federal government caused by a major erosion-induced property loss that results

in decreased income tax liability for the affected taxpayer.

5) Loss of area aesthetics and community well-being.

6) Loss of local citizens' "peace of mind" as their properties or neighboring properties are constantly threatened by persistent shore erosion.

For the purpose of this study, only the first two categories of erosion damages are considered tangible and quantifiable. Therefore, the computation of future erosion-induced losses will be limited to those attributed to recreation losses, loss of residential structures, and loss of residential land. A complete documentation of the methods used to compute these losses is contained in Appendix F.

Estimates of bluff loss have been determined for Condition No. 2 (Condition No. 3 is the same as Condition No. 2) by measuring from the actual 1973 bluff to the 2023 A.D. bluff. The Condition No. 1 bluff that is predicted for 2023 A.D. is also presented showing the effect that the harbor structures as well as the private shore protection works have on future bluff position. Future loss calculation is not measured from this Condition No. 1 bluffline, however, since this condition is truly hypothetical. A composite drawing showing the predicted bluffline in the year 2023 A.D. for Conditions 1, 2, and 3 is presented in Figures 5.0.1A-C. The actual 1973 bluff and shoreline are also shown.

The value of the expected annual loss of recreational usage at Sherod Park and City Beach was determined using the methods set forth in Appendix F utilizing the guidance provided by Buffalo District personnel. Because virtually no attendance data were available for either Sherod Park or City Beach, a number of subjective judgments were made to determine the value of such pertinent factors as park utilization, season of usage, expected growth in future demand for recreational resources, and the monetary "value" that can be attributed to a visit to each of these public parks even though at the present time, no fee for visitation is charged. A comprehensive discussion of

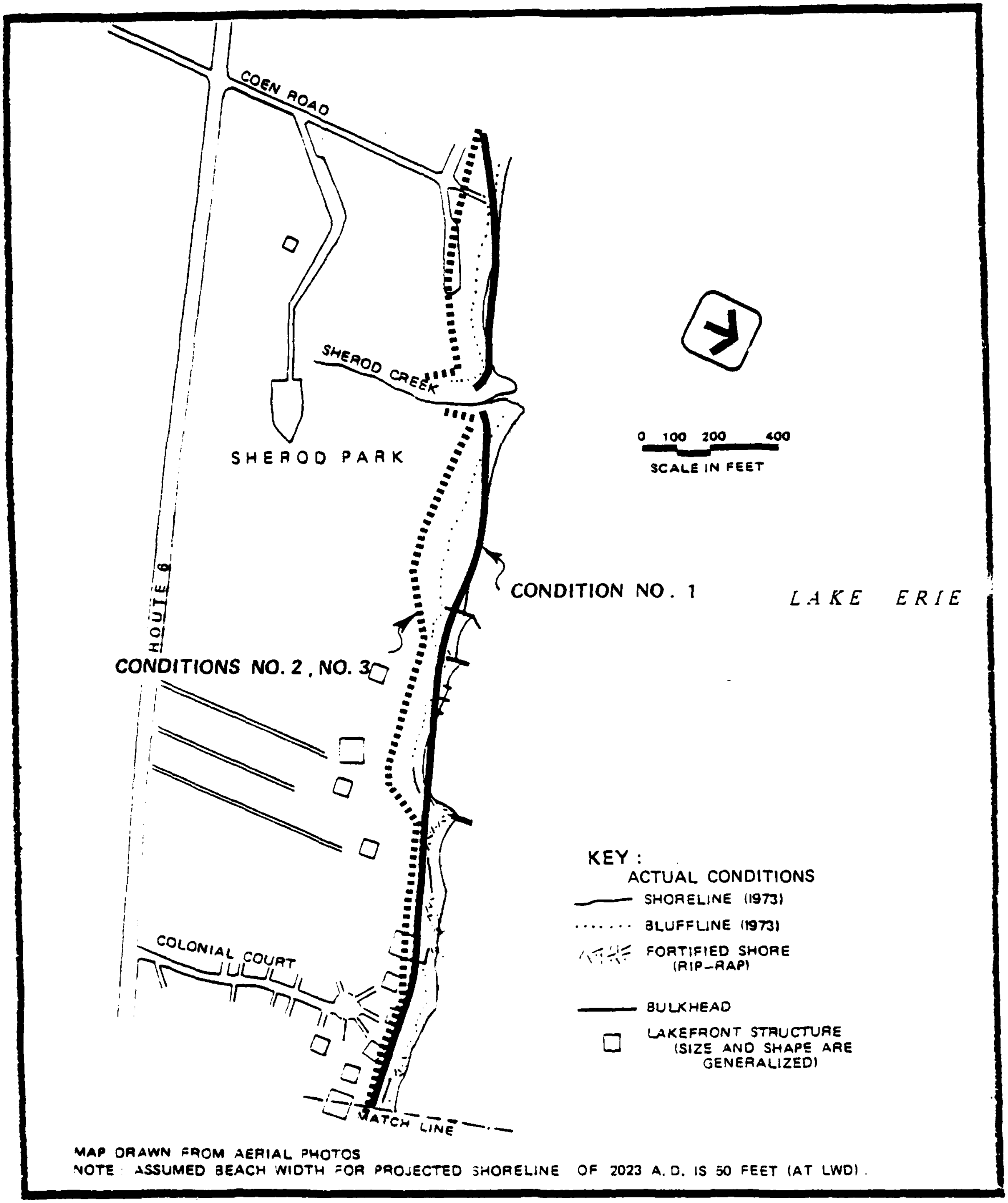
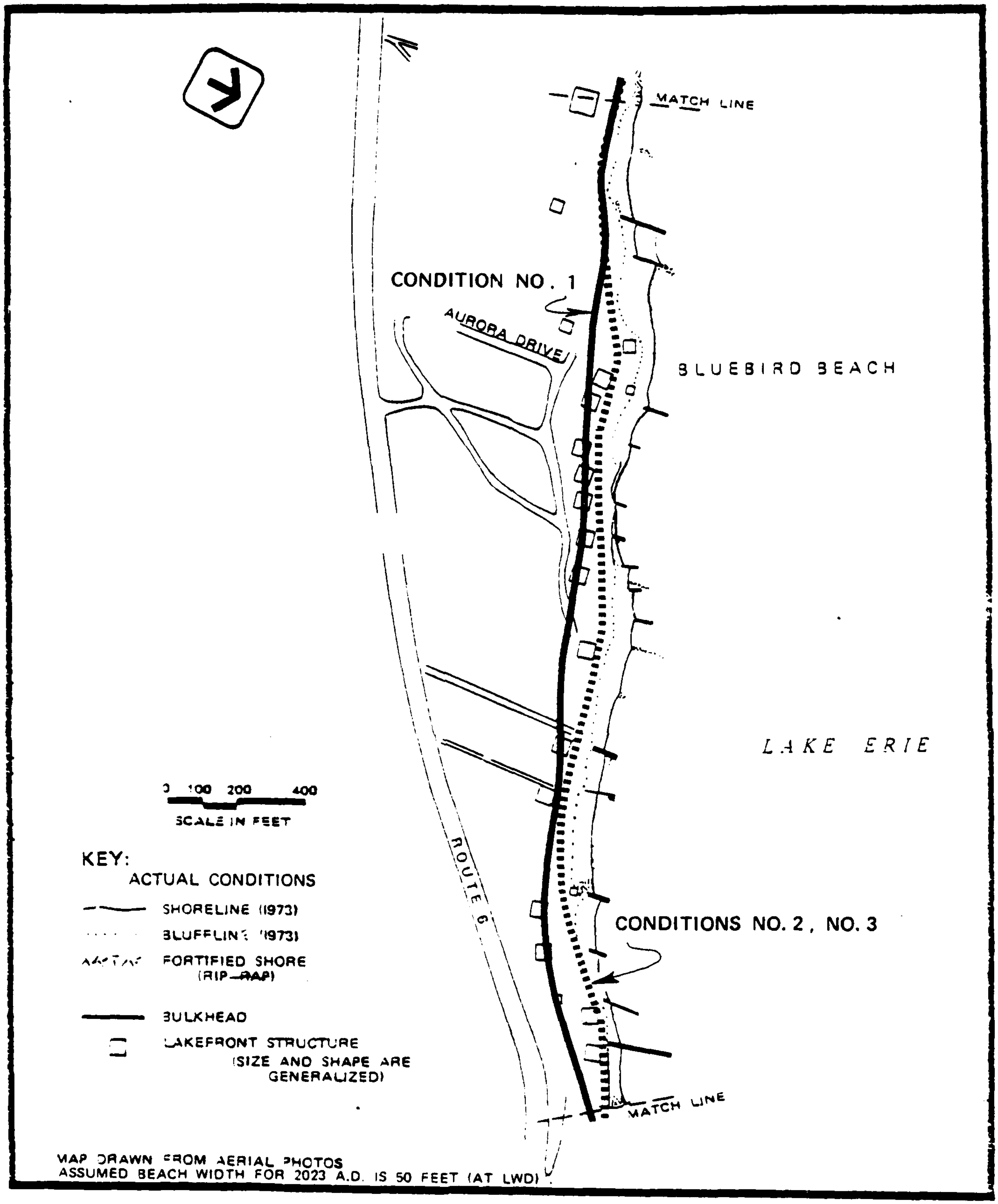


FIGURE 5.0.1.A: PREDICTED BLUFFLINES—2023 A. D.



FIGURF 5.0.1.B: PREDICTED BLUFFLINES—2023 A. D.

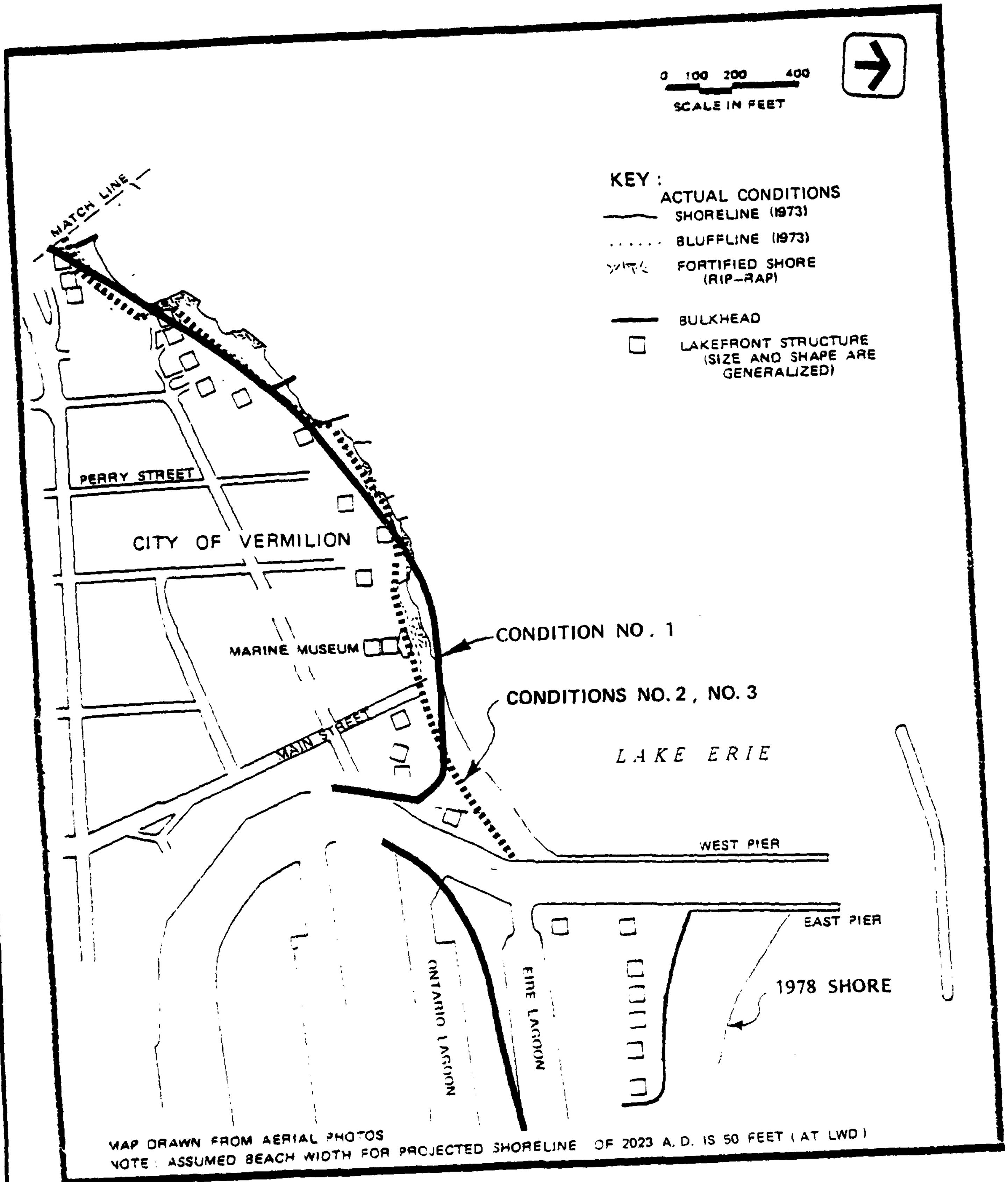


FIGURE 5.0.1. C : PREDICTED BLUFFLINES—2023 A. D.

the methods used to compute the future losses in recreation if the existing shore erosion continues is contained in Appendix F. In summary, the expected average annual recreational losses caused by existing erosion at Sherod Park are $3,026 and at City Beach are $83. These losses are based on the assumed value of a visit to these parks equal to $1.75/visit at Sherod Park and $1.50 at City Beach that was computed using the accepted government document that specifies the method of computation based on a number of criteria (Water Resources Council, 1975).

The future value of erosion-induced losses to residential structures was also computed, as shown in Appendix F. If a recession line to 2023 A.D. as shown in Figures 5.0.1A-C passes through a structure, it is assumed that that structure will be adversely affected by the ongoing shore erosion processes active at its location. One may assume that either the structure will be abandoned and lost to the lake in the future, or that at some point prior to structure loss, the bluff upon which the structure rests will be stabilized by the homeowner. The shoreline change analysis performed in this study has allowed the identification of structures that will be adversely impacted by erosion prior to 2023 A.D. Based on the belief that shore and bluff protection is less costly than the total loss of a structure to the lake, the future cost of structure loss can be measured in terms of the cost of bluff protection at some time prior to the inundation of the structure's foundation. For the purpose of this calculation, it has been assumed that at the time the bluff retreats to within ten feet of the structure, a 100-foot long armor stone revetment will be constructed by the homeowner at the base of the bluff. The approximate cost of this construction in 1980 is $35,000, as computed in Appendix F. Thus, future structure losses can be considered to be a number of cash outlays (equal to $35,000 in 1980) in future years by the owner of each threatened structure. By establishing a "present value" of each of these individual expenditures, a total present value of all expenditures can be determined and subsequently amortized over the next fifty year period using an annual interest rate of 7-1/8 percent. This amortization yields the average annual value of future damage caused to residential structures by shore/bluff erosion. This can be considered the average annual <u>benefit</u> of any erosion mitigation scheme that will stop

the ongoing erosion processes and thereby eliminate the need for future shore protection expenditures by private interests along the study reach. Complete documentation and computations of the benefits attributed to structure preservation are contained within Appendix F. The average annual benefit computed that is attributed to the protection of private structures along the study reach is estimated to be $7,700.

The value of the anticipated loss of residential property has been estimated using information gained from various real estate brokers in Vermilion. The general opinion is that while there currently exists a wide range of costs for lakefront homes in the study area ($30,000-$250,000+), there is an extremely high demand for lakefront property. There is no undeveloped private lakefront in the study area. East of the harbor, however, undeveloped lakefront lots having dimensions of 90' x 200' are currently being sold for about $40,000. This equates to $2.25 per square foot and it is this unit cost that is used to determine the value of the bluff property lost due to coastal erosion to the year 2023 A.D. Close inspection of the erosional trend along the study reach shows that an average annual area of 4,190 square feet of residential property is currently eroded from the bluff (see Appendix F). Applying a unit value of $2.25/square foot for this loss, the annual residential land loss along the study reach is $9,428.

5.1 ESTIMATED DAMAGE FOR SHORELINE CONDITION NO. 2 (Harbor Piers Only) AND SHORELINE CONDITION NO. 3 (Harbor Piers and Breakwater)

As mentioned in Section 4.3, the future shore and bluff losses to the west of Vermilion Harbor are not altered measurably by the offshore breakwater. Therefore, the future losses for Conditions 2 and 3 are considered to be equivalent and are estimated to the year 2023 A.D. in Table 4.

Aerial photos taken since the breakwater construction show a trend towards shoreline accretion along the beach immediately west of Vermilion Harbor. (See Figures 3.3.5 and 3.6.1.2). This is due to the sheltering effect of the harbor structures that prohibits the westerly transport of littoral material out of this region during northeast storm

	Loss To 2023 A.D.	Value Of Loss To 2023	Ave. Annual Loss
I. LOSS OF RECREATIONAL USAGE+			
A. Sherod Park	94,500 SF	$151,290	$3,026
B. Vermilion City Beach/ Museum Property	3,000 SF	4,125	83
II. LOSS OF RESIDENTIAL LAND+ (Unit Value = $2.25/SF Based on 1980 Real Estate Data)	209,500 SF	471,375	9,428
III. LOSS OF RESIDENTIAL STRUCTURES+	(6 Structures)	104,610*	7,700
	TOTAL	$ 731,400	$20,237

1980 Dollars
+ Computation Contained in Appendix F
* Present worth, annualized by i = 7-1/8 percent, n = 50 years

TABLE 4 : EXPECTED LOSSES, 1973- 2023 A.D.

Shoreline Condition No. 2 and Shoreline Condition No. 3

events. Because this beach growth occurs on private property, no public benefit is received.

It can be added that the existence of the harbor piers has created substantial benefits for the shore immediately east of Vermilion Harbor. As shown in Figure 4.1.1 D, sediment blockage at the east pier has created a parcel of land of approximately 20 acres. Landward of this accreted beach, numerous homes and summer cottages have been constructed. The benefits attributed to the shore protection that this beach provides to upland properties are considered to be "intangible" for this economic analysis and cannot be considered to compensate for shoreline damage on the west side of the harbor attributable to the navigation structures.

6.0 MITIGATION OF SHORELINE DAMAGE

6.1 GENERAL

The consideration of actions to mitigate shoreline damage to the west of Vermilion Harbor is based on the evaluation of the harbor structures influence on the shoreline changes identified in Section 4.0.

In summary:

- Coen Road is considered to be the limit of shoreline influence of the Federal navigation works to the west of Vermilion Harbor. This reach contains approximately 8,100 feet of shoreline west of the west pier structure.
- The effects of the navigation works on this shoreline prior to the construction of the offshore detached breakwater were to aggravate an existing erosional condition. The new rate of erosion averaged over approximately 40 years of aerial photo coverage was calculated to be 1.4 feet/year for stretches of shoreline which have not been privately protected. This rapid erosion did not occur in the shore areas just west of the west piers, however, because private protective works were constructed as the city of Vermilion expanded to the west from the harbor. Only in the unprotected shoreline area near Sherod Park is this erosion evident. In comparison, a "natural erosion rate" for this area, had there been no navigation or private protective structures, was estimated at 1.0 ft./yr based upon approximately 100 years of Ohio Division of Geological Survey data.

Therefore, the portion of the total erosion attributable to the Federal Navigation works alone is estimated to be 29 percent $\left(= \frac{0.4}{1.4}\right)$ of the total erosion. For this reason, the total loss values shown in Table 4 must be decreased to 29 percent of the total to express the damage caused by the

harbor structures alone. Thus, the average annual loss attributable to the Federal navigation structures under existing conditions at Vermilion Harbor is $5,870 (= 29 percent of $20,237, the total damage given in Table 4). In future sections of this report, these losses will be treated as project benefits for the various erosion mitigation measures proposed. At that time, the specific losses/benefits that apply to each mitigation alternative will be discussed.

- In the brief period since the construction of the offshore detached breakwater, no net effect of this new navigation work can be surmised. Local effects of this breakwater are apparent due to its "shadow" effect for waves from the northeast. These, however, are limited to a redistribution of beach material in the Marine Museum/City Beach area causing a sand fillet to develop adjacent to the west pier. The offshore breakwater has had such a limited effect on the shoreline west of Vermilion Harbor mainly because its sole influence has been to further limit the small amount of littoral material (3,400 C.Y./year) that previously bypassed the harbor piers.

There may appear to be no apparent damage (erosion) of some sections of shoreline west of Vermilion Harbor in recent years due to the private protective works built in this area. However, mitigation for the 3100 feet of shoreline west of Vermilion Harbor should be considered in light of past damages and in anticipation of future effects of the Federal navigation works.

The alternatives which will be considered in this study for mitigation of shoreline damages will be combinations of the following methods:

- Beach Restoration - A onetime beach widening program to replace what natural forces have removed due to the deficiency of littoral material that has been blocked by the navigation works.

A widened beach reduces lake-induced bluff erosion.

- o Beach Nourishment - A continuing program which will annually place in the littoral zone beach material that will compensate for the erosion that is attributable to the Federal navigation works.
- o Structural Modification - To prevent the beach material placed during restoration and nourishment procedures from being rapidly eroded away and/or to structurally protect the shoreline from additional erosion in the future.

Computations performed in the economic analysis of each alternative are shown in Appendix F of this report.

6.2 ALTERNATIVE I - Beach Nourishment (Maximum Federal Responsibility)

This alternative plan involves the following features:

- o Construction of a new 210 foot long groin just west of the Marine Museum;
- o A 20 ft. wide beach restoration for 360 feet east of this new groin;
- o A 20 ft. wide beach restoration west of the new groin extending to Coen Road; and
- o A beach nourishment program which will deposit 2123 cubic yards of suitable material per year in three equal 708 cubic yard portions at stations 29, 52, and 74 between the new groin and Coen Road.

See Figure 6.2.1 for Alternative I physical features. The compu- computations which support this analysis are contained within Appendix E.

The construction of the new groin at the Marine Museum is considered to be a necessary part of the maximum Federal responsibility. This groin will be located and orientated such that it will only allow the movement

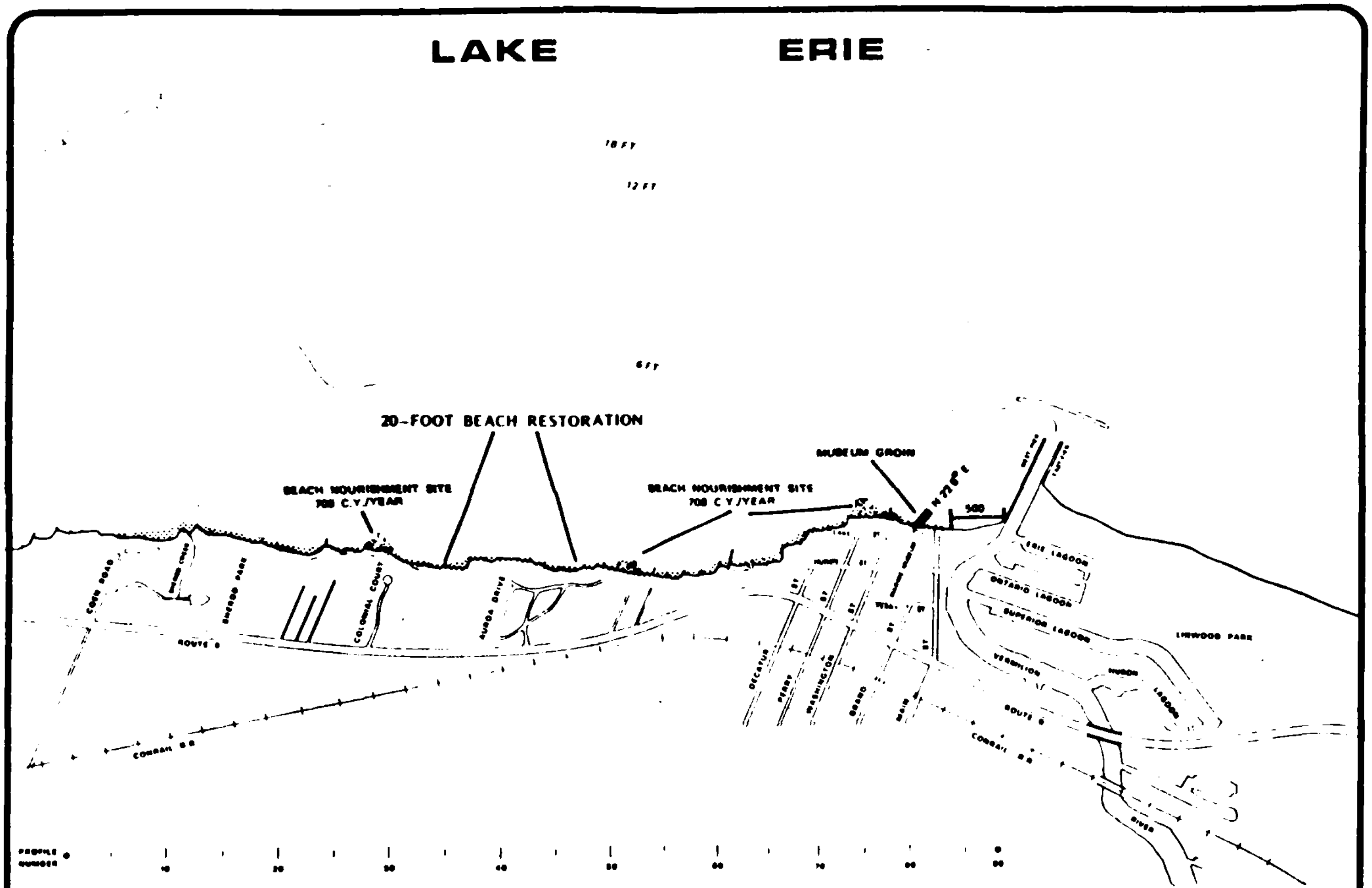


FIGURE 6.2.1
VERMILION HARBOR, OHIO

MITIGATION ALTERNATIVE I
BEACH NOURISHMENT
FEDERAL PARTICIPATION ONLY

TETRA TECH
Pasadena, California

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6-4

of restoration and nourishment material to shorelines west of its location (885 feet west of the west pier). If this groin were not placed here, waves from westerly directions would drive the newly placed material easterly and into the "shadow" zone behind the offshore breakwater. This material would be unavailable for transport back to the west when the wave climate changes and, therefore, larger quantities of nourishment material would be needed to accomplish the mitigation objectives.

An additional effect of the groin would be to provide protection for the pocket beach located between the groin and the west harbor pier. In this area a 360 ft. portion of City Beach and property fronting the Museum will be restored to negate effects of past erosion. The shoreline within this pocket will be very stable being sheltered from northeast and northwest waves.

West of this groin to Coen Road, a 20-foot wide beach will be restored to compensate for past erosion caused by the Federal navigation works. This will not only provide much needed beach material in the littoral zone, but it will also provide a degree of protection to the bluffs behind the beach by expending wave energy seaward of the bluff face.

Periodic nourishment of the shoreline west of the Marine Museum groin is the key element in this mitigation plan. This feature provides for an amount of nourishment equivalent to the amount of material eroded due to the presence of the navigation works. This is the difference between the aggravated erosion rate caused by the navigation structures and the natural erosion rate of this stretch of shoreline had no structures been built. The U.S. Army Corps of Engineers has concluded, at least for the proposed mitigation measures east of Vermilion Harbor, that periodic nourishment of this type is within the scope of Section 111 authority.

The amount of nourishment was found by comparing the aggravated erosion rate of 1.4 feet/year to the natural erosion rate of 1.0 feet/year and determining the equivalent amount of beach material in cubic yards per year needed to make up the 0.4 ft./yr. difference over the approximately 7100 feet of shoreline from Coen Road to the Museum groin. It was further determined

that more than one nourishment area would be needed for the proper dispersal of this material by natural processes. Accordingly, a cursory examination of the area led to the choice of three sites for possible nourishment deposits. These suggested locations are at stations 29, 52 and 74 on the layout map (Figure 6.2.1). However, subsequent detailed analysis of access routes may lead to other choices.

Three sources of material for the restoration and nourishment programs have been identified but only one appears to be feasible at this time. These are:

- o Material bypassed from the fillet east of the Vermilion East Pier;
- o Material dredged from the harbor approach channels as part of normal harbor maintenance; and
- o Material brought in from an outside source either dredged from lake deposits or trucked in from local sources.

The first source is being considered by the Buffalo District for back-pass operations to Linwood Beach if local approval can be obtained. The second source has been declared unsuitable in recent (July 1978 and October 1979) Corps surveys in the area. Thus, external sources of sand are presently the primary alternative and cost estiamtes for the mitigation plans are calculated accordingly.

Detailed design caluclations and cost estimates are provided in Appendix E of this report, however, a summary of the cost analysis is presented in Table 5. The first three features of Alternative I are one time construction items that include blanket and armor material for the Museum groin construction, 1087 cubic yards of beach fill to restore the Museum/City Beach area, and 12,940 cubic yards of beach fill to restore the shoreline between the Museum groin and Coen Road. After appropriate contingencies and fees are applied to these items, a total first cost for these features comes to $233,300.

TABLE 5

ALTERNATIVE I, COST COMPUTATION

First Costs:	Quantity	Unit Price	Cost
Marine Museum Groin			
Blanket Material	500 C.Y.	$27/C.Y.	13500
Head Armor	53 Tons	33/Ton	1750
Trunk Armor	960 Tons	33/Ton	31680
Museum/City Beach Restoration	1,087 C.Y.	10/C.Y.	10870
Shoreline Restoration	12,940 C.Y.	10/C.Y.	129400
Subtotal			187200
Contingency (15%)			28080
Subtotal			215280
Engineering/Design (20%)			43056
Supervision/Inspection (6%)			12917
Overhead (5.6%)			12056
Total First Cost:			$283,300

Annual Costs:

Annual Cost, First Cost Items (i=7 1/8%, n=50 yrs., CRF=0.07361)	$20,850
Maintenance Costs	
5% of First Cost of Groin + Fees	3,550
Beach Nourishment	
Maximum Federal Participation (2123 C.Y. @ $10/C.Y.)	21,230
TOTAL ANNUAL COST	$45,630

Utilizing an interest rate of 7 1/8 percent, with a 50 year useful life, the annual cost of investment would be $20,850. To this annual cost must be added the estimated annual maintenance costs of 5% on the first cost of all fixed structures of $3,550. The remaining cost feature of the Alternative I plan is the annual cost of beach nourishment estimated to be $21,230 for 2123 cubic yards of beach fill per year. This brings the total annual cost of Alternative I mitigation plan to $45,630.

Benefits derived from this mitigation plan are based primarily upon the degree to which the plan postpones or counteracts the expected losses calculated in Section 5.0 (Impact of the Harbor Structures). The analyses that support these benefit calculations are contained in Appendix F.

Because of the construction of the Marine Museum groin, the expected loss of 3,000 square feet of beach fronting the Museum and City Beach will be prevented. Due to the protection that this groin affords, the 20 foot x 360 foot beach restoration in the City Beach area will be maintained over the project life and will provide a recreational beach use benefit.

Sherod Park, at the west end of the 8100 foot zone of influence of the navigation structures, is another public area whose protection will provide recreational benefits. Because of the 20 foot wide shoreline restoration and beach nourishment program, the erosion at Sherod Park will be stopped for the first 20 years while the restored beach protects the bluff. Thereafter, for the remaining 30 years of project life, the erosion will continue but at the lower natural erosion rate (= 1 ft/year) because of the beach noruishment program. The average annual benefit for protection of existing recreational land at these two parks is $902; the recreational benefit for the proposed beach construction is $28,912.

An added benefit is derived from the reduced rate of loss of residential land and structures on the private property between the west pier and Coen Road. The annual benefits for protection of residential land (= $9428) and residential structures (= $7700) is $17,128, however, only 29% of this total can be applied to the mitigation of Federal structure-induced damage. Therefore, this benefit is reduced to $4,967 for the economic analysis.

The total annual average benefits of mitigation Alternative I are thus $34,781. The estimated benefit/cost ratio is $34,781/$45,630 or 0.76.

6.3 ALTERNATIVE II - Beach Nourishment: Optimum Plan

This alternative plan involves the same four features outlined for Alternative I plan plus:

- A beach nourishment program which will replace on an annual basis the amount of sand eroded by natural forces at the pre-navigation works erosion rate (i.e. the natural erosion rate of 1.0 feet/year). Figure 6.3.1 illustrates the physical features of Alternative II. The quantity of material required over the 7100 feet of shoreline from the Museum groin to Coen Road is 5,261 cubic yards per year. When this is added to the 2,123 c.y./yr. being placed as the maximum Federal responsibility, a total of 7,384 c.y./yr. will be deposited in three equal parcels of 2,461 c.y./yr. at the three stations previously specified (stations 29, 52 and 74), Theoretically, the placement of this total quantity of nourishment per year should stabilize the shoreline at its restored position and thus prevent any future bluff loss due to wave erosion. Thus, this plan artifically replaces a quantity of material on the beaches equivalent to that which is expected to erode under existing conditions.

Since the shoreline would be stabilized, this alternative would provide a degree of protection beyond the intent of the Section 111 authority. A portion of the costs of this alternative, over and above the maximum cost of Federal participation must therefore be borne by non-Federal interests.

All costs and benefit computations are presented in Appendix E and F of this report.

The total first costs of the Marine Museum groin construction, the Museum/City Beach restoration, and the remaining shoreline restoration are shown in Table 6, and are identical to that of Alternative I. The annual cost of beach nourishment would consist of $21,230 for maximum Federal participation and an additional $52,610 for the 5,261 yd^3 per year of non-Federal nourishment. The total annual cost of the Alternative II mitigation plan is $98,200.

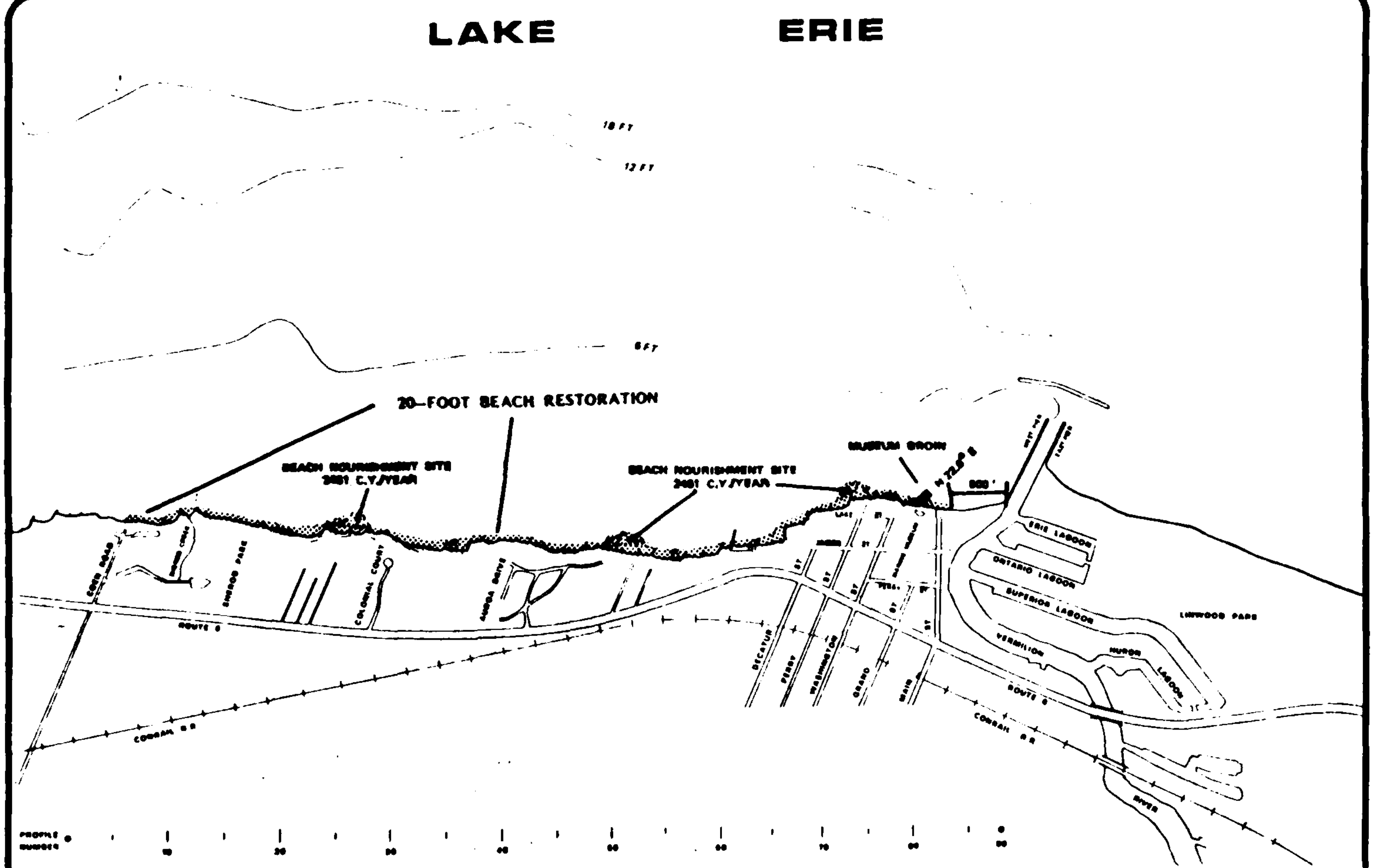

FIGURE 6.2.1.
VERMILION HARBOR, OHIO

MITIGATION ALTERNATIVE II
BEACH NOURISHMENT
FEDERAL + LOCAL PARTICIPATION

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Pasadena, California

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TABLE 6

ALTERNATIVE II, COST COMPUTATION

First Costs:	Cost
Marine Museum Groin (As Computed, Table 5)	$ 46,930
Museum/City Beach Restoration (As Computed, Table 5)	10,870
Shoreline Restoration (As Computed, Table 5)	129,400
Subtotal	$187,200
Contingency (15%)	28,080
Subtotal	215,280
Engineering/Design (20%)	43,056
Supervision/Inspection (6%)	12,917
Overhead (5.6%)	12,056
Total First Cost	$283,300
Annual Cost:	
Annual Cost, First Cost Items ($i=7\frac{1}{8}$, n=50 yrs., CRF=0.07361)	$ 20,850
Maintenance Cost (5% of Groin Cost - Fees)	3,550
Beach Nourishment	
Maximum Federal Participation (2123 C.Y. @ $10/C.Y.)	21,230
Local Participation (5261 C.Y. @ $10/C.Y.)	52,610
TOTAL ANNUAL COST	$98,200

As in Alternative I, the Museum/City Beach area is restored and protected for the 50 year project life.

In the Sherod Park area, the bluffline is stabilized against erosion because the shoreline would be widened and stabilized by the upgraded nourishment program. Since the bluff would not erode over a 50 year period, an annual benefit is derived for recreation area saved from erosion. Similarily, if the nourishment program creates a stable shoreline, the 20 foot wide beach restoration can be counted as a recreational benefit which will not decrease over a 50 year project life. The estimated average annual benefit for protection of existing recreation is $902. The benefits attributable to constructed beach recreation is $34,556 annually.

Residential land and structures will also be saved under a stable shoreline condition. The full value of this benefit is $17,128 per year; reducing to 29% of this total yields the annual benefit of $4,967. The total benefits attributed to Alternative II is $40,425. The benefit/cost ratio for this alternative is $40,425/$98,200 or 0.41.

6.4 ALTERNATIVE III - Beach Nourishment And Short Groin Cons· uction

This alternative plan utilizes the same five features as the Alternative II plan except for the amount of beach nourishment required as non-Federal participation. In this plan, a series of eleven short (approximately 33 feet long) groins will be constructed at chosen locations between the Museum groin and Coen Road. These locations are chosen so that the groins add to the trapping capacity of existing structures and retain a portion of the nourishment material. The trade off between this and Alternative II is an increased efficiency to retain a beach fronting the bluffs using a series of groins versus using an increased volume of nourishment material and only the existing structures to contain this material.

Assuming a fifty percent trapping efficiency for each new groin, the amount of annual nourishment can be reduced fifty percent to maintain a shoreline stability. If 7,384 yd^3/yr were previously needed to maintain stability, only 3,692 yd^3/yr are required under this plan. Since the minimum Federal participation requires for 2,123 yd^3/yr, the remainder of 1,569 yd^3/yr must be provided by non-Federal participation. The total 3,692 cubic yards would be placed in three equal deposits of 1,231 yd^3/yr at stations 29, 52, and 74. The location of the eleven short groins and the proposed nourishment sites are shown on Figure 6.4.1 along with other features of Alternative III.

The first cost features of Alternative III are shown in Table 7 and include the Marine Museum groin construction, the restoration of Museum/City Beach, shoreline restoration from the Museum groin to Coen Road, and the construction of eleven short groins. The total first cost of Alternative III is estimated at $461,930.

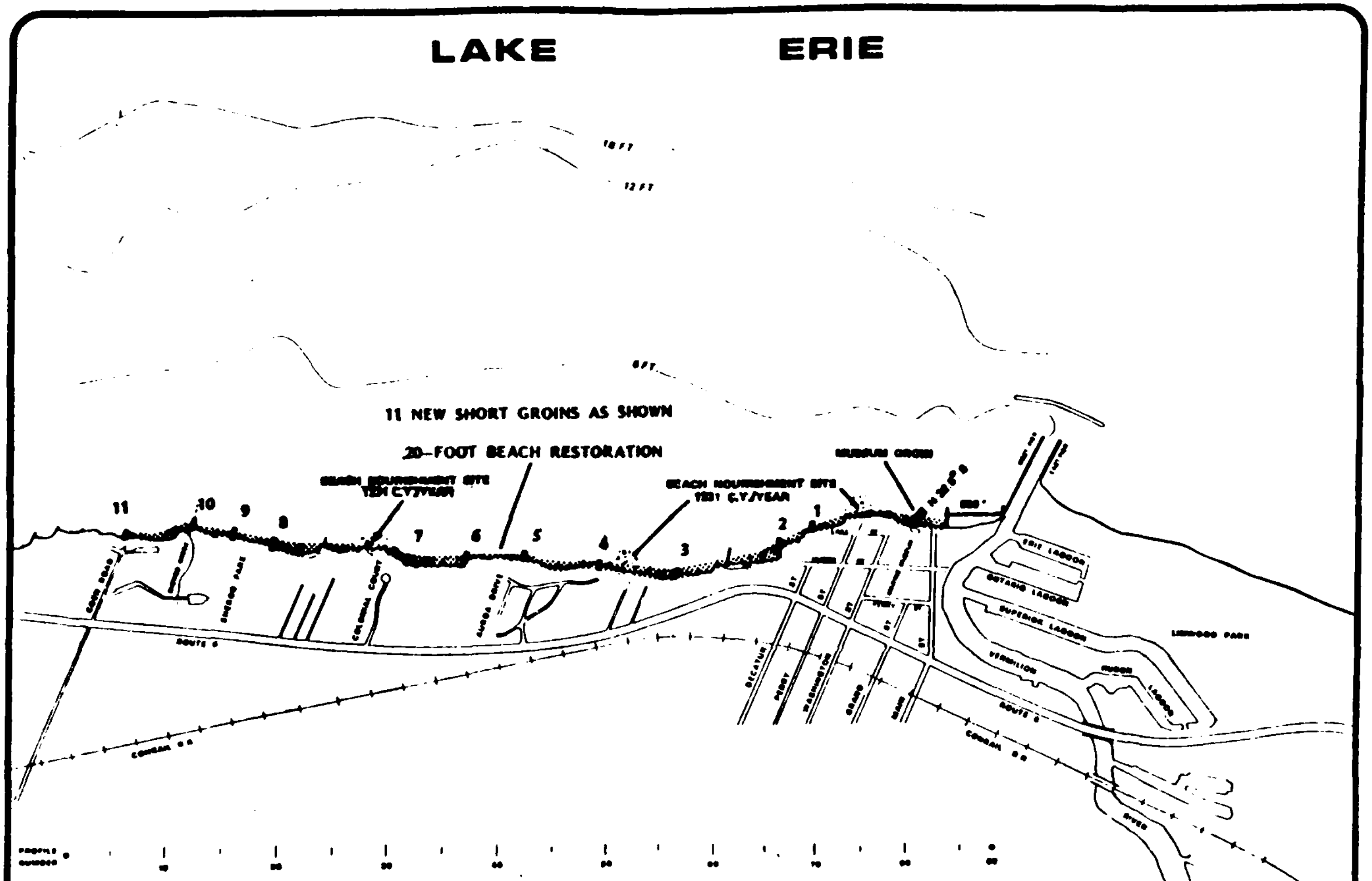

FIGURE 6.4.1
VERMILION HARBOR, OHIO

MITIGATION ALTERNATIVE III
BEACH NOURISHMENT &
GROIN CONSTRUCTION

TETRA TECH
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Date
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of

TABLE 7

<u>ALTERNATIVE III, COST COMPUTATION</u>

First Costs:			Cost
Marine Museum Groin Construction (As Computed, Table 5)			$46,930
Marine/City Beach Restoration (As Computed, Table 5)			10,370
11 Short Groins	Quantity	Unit Cost	
Excavation/Rehandling	2,400 C.Y.	$7.50/C.Y.	18,000
Blanket Material	935 C.Y.	27/C.Y.	25,250
Armor Rock	2245 Tons	44 Tons	98,730
Shoreline Restoration	10540 C.Y.	10/C.Y.	105,400
Subtotal			305,230
Contingency (15%)			45,785
Subtotal			351,015
Engineering/Design (20%)			70,203
Supervision/Inspection (6%)			21,060
Overhead (5.6%)			19,657
TOTAL FIRST COST:			$461,930
Annual Costs:			
Annual Cost, First Cost Items ($i=7\frac{1}{8}\%$, n=50 yrs.,CRF=0.07361)			$ 34,000
Maintenance Cost (5% of Groin Cost + Fees)			14,300
Beach Nourishment			
Maximum Federal Participation (2123 C.Y. @ $10/C.Y.)			21,230
Local Participation (1569 C.Y. @ $10/C.Y.)			15,690
TOTAL ANNUAL COST			$ 85,220

The annual cost for the first cost items mentioned above is $34,000 (using an interest rate of 7 1/8 percent and a 50 year life). Average annual maintenance costs on the fixed structures are $14,300 and the annual cost of beach nourishment features are $21,730 for Federal participation and $15,690 for non-Federal participation. The total annual cost for Alternative III is therefore $85,220.

Since the net effect of this plan is to create a stable shoreline as in Alternative II, the assumed benefits are $40,425 per year as calculated for Alternative II. The benefit/cost ratio for Mitigation Alternative III is then $40,425/$85,220 or 0.47.

6.5 ALTERNATIVE IV - Bluff Revetment

This alternative plan involves the following features:

- Construction of a new 210-foot long groin fronting the Marine Museum;
- A 20-foot wide beach restoration for 360-feet east of this new groin; and
- Construction of revetment for bluff protection extending from the Museum groin west to Coen Road.

The use of a revetment in this plan is a structural alternative to beach restoration and nourishment. It is the most effective means of maintaining the bluff in a stable position. Over the 50 year life of the project, one would expect no bluff-line loss at Sherod Park and no residential land or structure loss in the private property areas.

The shoreline east of the Museum groin will not be reveted because of the protection offered by the groin and the harbor structures. The beach will be restored in the 360-foot length where erosion has previously taken place. See Figure 6.5.1 for physical features of Mitigation Alternative IV.

All features of this plan are first cost items as shown in Table 8 that include the construction of the Museum groin, the City Beach restoration, and the construction of the approximately 7100 feet of bluff revetment. With contingency and fees, the total first cost for Alternative IV is $4,386,700.

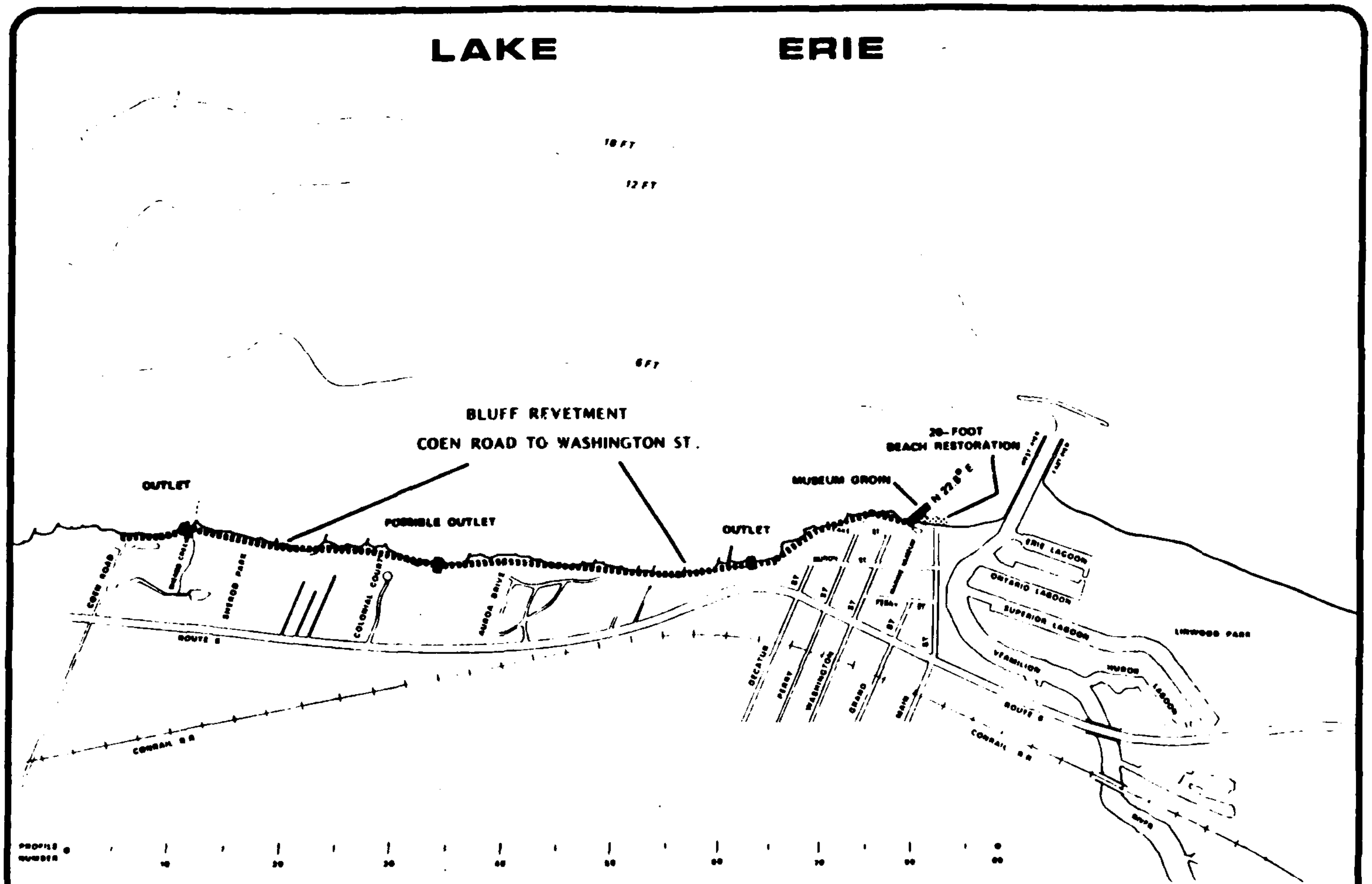

FIGURE 6.5.1.
VERMILION HARBOR, OHIO

MITIGATION ALTERNATIVE IV
BLUFF REVETMENT

TETRA TECH
Pasadena, California

TABLE 8

ALTERNATIVE IV, COST COMPUTATION

First Costs:	Quantity	Unit Cost	Cost
Marine Museum Groin (As Computed, Table 5)			$ 46,930
Museum/City Beach Restoration (As Computed, Table 5)			10,370
Bluff Revetment			
Blanket Material	22,510 C.Y.	$27/C.Y.	607,770
Underlayer	11,632 Tons	40/Tons	465,280
Armor Stone	34,949 Tons	44/Tons	1,537,760
Subtotal			$2,668,610
Contingency (15%)			400,290
Subtotal			3,068,900
Engineering/Design (20%)			613,800
Supervision/Inspection (6%)			184,100
Overhead (5.5%)			171,350
TOTAL FIRST COST:			$4,386,700
Annual Costs:			
Annual Cost, First Cost Items ($i=7\frac{1}{3}\%$, n=50 yrs.,CRF=0.07361)			297,300
Maintenance Costs (5% of Groins Cost + Fees)			200,700
TOTAL ANNUAL COST			$498,000

In order to do a benefit/cost analysis, this first cost was converted to an equivalent annual cost on investment for the 50 year project life of $297,300. Add to this the estimated annual average maintenance costs at five percent of first costs of structures or $200,700 for a total annual cost for Alternative IV of $498,000.

All benefits for Alternatives II and III are applicable to Alternative IV except that there are no recreational beach benefits at Sherod Park. The annual benefit of a stable bluffline in terms of savings of residential land

and property is $17,128. Since only 29% of the ongoing erosion is attributable to the Federal structures, this benefit is reduced to $4,967. The recreational benefits that occur from the saving of existing beach is $902; and that for construction of the proposed beach is $10,082. Thus, the total benefits for Alternative IV is $15,951. The benefit cost ratio, therefore, is $15,951/ $498,000= 0.032.

6.6 "NO-ACTION" ALTERNATIVE

If none of the four erosion mitigation alternatives are deemed suitable due to economic, environmental, social, institutional, and/or financial considerations, the "No-Action" alternative may be the only alternative that is feasible. Currently, the total annual damages due to losses of residential land and structures, and to loss of recreational resources along the study reach total $20,237, as shown in Table 4. If no action is taken, these average annual losses will continue in the future. It has been determined that only 29% of the total erosion occurring within the study reach can be attributed to the Federal harbor structures at Vermilion. Therefore, in terms of erosion mitigation under Section 111 authority, only the value of the erosion induced by the Federal structures can be considered in the economics of the mitigation alternatives. Thus, $5,870 (29% of $20,237) is judged to be the total annual damage attributable to the harbor structures that will occur in the future if no mitigative action is taken.

6.7 ECONOMIC ANALYSIS AND ENVIRONMENTAL IMPACT SUMMARY

On the following page, Table 9 summarizes the estimated costs and benefits for the four alternative plans evaluated. The engineering and economic analyses presented here do not consider environmental issues which may have an overriding influence on whether a plan is feasible or not. Also, there may be environmental impacts of a specific plan which would favor that plan but are not quantifiable monetarily and, therefore, cannot be considered in the benefit/cost analysis.

	I: BEACH NOURISHMENT MAXIMUM FEDERAL RESPONSIBILITY	II: BEACH NOURISHMENT OPTIMUM PLAN	III: BEACH NOURISHMENT SHORT GROINS	IV: BLUFF REVETMENT
ESTIMATED FIRST COSTS	$283,300	$283,300	$461,930	$4,038,700
ESTIMATED ANNUAL COSTS				
INTEREST & AMORTIZATION	20,850	20,850	34,000	297,300
ANNUAL MAINTENANCE	3,550	3,550	14,300	200,700
BEACH NOURISHMENT	21,230	73,840	21,230	0
TOTAL	$ 45,630	$ 98,200	$ 85,220	$498,000
ESTIMATED ANNUAL BENEFITS	$ 34,781	$ 40,425	$ 40,425	$ 15,951
BENEFIT/COST RATIO	0.76	0.41	0.47	0.032

TABLE 9: ECONOMIC ANALYSIS SUMMARY

In general, adverse environmental impacts associated with these plans would include, but not be limited to, noise and air pollution from construction equipment, turbidity of lake waters during construction and periods of beach nourishment, destruction of aquatic plants and animals under filled or constructed areas and in turbid waters, unfavorable beach access in the plans that require bluff revetment and groin construction, area aesthetics for the groin construction alternatives, and possible downdrift effects of tampering with the littoral system.

In general, positive environmental impacts would include but not be limited to, a stable shoreline and attendant increase in property values, increased recreational useage in some plans, a favorable effect on aesthetics in the case of the revetment plan (instead of sloughing slopes) and an increase in supply of littoral material to downstream shores in all but the revetment plan.

6.8 COST ALLOCATION

Under the authority of Section 111 of Public Law 90-483, Federal participation in the cost of a plan to mitigate shore erosion adjacent to Federal Structures serving navigation is limited to that portion of the erosion problem attributable solely to the structures. Of the four alternatives evaluated in this study, Alternative I is considered to be 100 percent within the authority of Federal cost participation and the allocation of costs for this plan would, accordingly, be all Federal. The remaining three alternative plans incorporate features which go beyond mitigation of damages due solely to the Federal navigation structures. These plans should prevent erosion attributable to natural processes as well as to the Federal navigation works. Cost allocation for these plans will, therefore, involve non-Federal participation. Federal cost participation in these plans would probably be limited to the Federal costs to perform Alternative I. Based on this rationale, the cost allocation for the four evaluated plans would be as shown in Table 10.

ESTIMATED COSTS	I BEACH NOURISHMENT MINIMUM FEDERAL PARTICIPATION	II BEACH NOURISHMENT OPTIMUM PLAN	III BEACH NOURISHMENT plus SHORT GROIN CONSTRUCTION	IV BLUFF REVETMENT
First Costs				
Federal	$283,300	$283,300	$283,300	$ 283,300
Non-Federal	0	0	178,630	4,103,400
Total	$283,300	$283,300	$461,930	$4,386,700
Annual Costs*				
Federal	$ 45,630	$ 45,630	$ 45,630	$ 45,630
Non-Federal	0	52,570	39,590	452,370
Total	$ 45,630	$ 98,200	$ 85,220	$ 498,000

NOTES

* Annual costs include an equivalent annual cost on first cost items in addition to annual cost items. Alternative I is assumed to be the maximum Federal responsibility and as such provides a basis of cost comparison to arrive at non-federal costs for other alternatives. The Federal portion contributed in Alternative I is considered the maximum Federal input for all alternatives.

TABLE 10: SUMMARY OF ESTIMATED FEDERAL AND NON-FEDERAL COSTS

6.9 CONCLUSIONS

An attempt has been made to define the impacts that the Federal navigation works at Vermilion Harbor, Ohio, have had on the shoreline to the west of these structures. It is evident that the fortification of these shores by private interests has masked the damaging effects of sediment blockage and diversion at the east harbor pier. Additionally, the armored nature of the western shoreline makes the impact of the offshore breakwater (constructed in 1973) indistinguishable from the impact of the harbor piers alone. In unprotected areas further to the west, it is clear that bluff erosion has been aggravated by the harbor piers and the subsequent armoring of adjacent shores. It is estimated that in these unprotected regions, 29% of the long-term bluff erosion rate is directly attributable to the Federal navigation structu[illegible]t Vermilion. Due to the historical armoring of the shores within the st[illegible] reach, substantial shore protection does exist in various areas of the [illegible]y reach yielding relatively low levels of ongoing erosion damage. The [illegible]ye damage attributable to the Vermilion harbor structures is $5,870. Four erosion mitigation alternatives have been presented that vary widely in their structure, cost, and impacts on adjacent shores. In addition, the "no-action" alternative has also been considered. Due to the relatively high construction costs, the benefit/cost analyses yield the conclusion that none of the structural alternatives considered are economically feasible (the highest benefit cost ratio achieved is 0.76).

7.0 THE RECOMMENDED PLAN

Because the annual benefits exceed the annual costs for all shore protection alternatives considered, it is judged that no action should be taken to mitigate the ongoing erosion that has been induced by the Federal harbor structures at Vermilion. The highest benefit/cost ratio achieved was for Alternative I with a value of 0.76. Because the great majority of project benefits could be attributed to additional recreational usage (due to beach construction) rather than to savings of presently eroding residential and public land and structures, it was deemed unwise to disregard the low benefit/cost ratios and support implementation of any mitigation alternative.

It must be understood that due to early shore protection measures constructed by private land owners in Vermilion, much of the shoreline along the study reach is relatively well-fortified (and, therefore, resistant to erosion-induced damage). The lack of justification for Section 111 mitigation to the west of Vermilion should not be construed as an indication of infeasibility of mitigation for the total reach (both east and west sides) affected by the harbor structures.

High level damages to the east of the harbor (if they exist) may require mitigative action that will lead to the acceptance of west side mitigative action as well. This evaluation must be determined in the Phase III Section 111 Study for the entire shore of Vermilion.

8.0 REFERENCES

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9.0 APPENDIX

TETRA TECH INC. PASADENA, CALIF.	SUBJECT: BLUFF SAND CONTRIBUTION – COEN ROAD TO VERMILION HARBOR	PROJECT: APPENDIX A
	COMPUTED: DGC CHECKED:	FILE NO:
		DATE: PAGE 1 OF 3 PAGES

PROFILE NO.	① BLUFF EROSION RATE (Ft/YR.)	② BLUFF HEIGHT (FT)	③ BLUFF SAND CONTRIBUTION (① × ② × $\frac{1}{27}$ × 15% × 100' C.Y. = ① × ② × 0.56 C.Y.) C.Y./LF/YEAR
6	-1.3	20	14.4
7	-1.7	20	13.9
8	-1.7	21	19.3
9	-1.7	20	13.9
10	-1.6	19	16.9
11	-1.3	16	11.6
12	-1.0	2	1.1
13	-1.3	19	13.7
14	-1.5	19	15.3
15	-1.3	19	19.0
16	-2.0	19	21.1
17	-1.9	20	21.1
18	-1.5	20	16.7
19	-1.4	20	15.6
20	-1.3	20	14.4
21	-1.4	19	14.3
22	-1.6	18	16.0
23	-1.6	16	[illegible]
24	-0.9	19	9.5
25	-1.0	19	10.6
26	-1.2	19	12.7
27	-1.4	19	14.3
28	-1.2	19	12.7
29	-0.3	19	3.4
30	-1.2	19	12.7
31	-1.4	18	14.0
32	-1.3	17	12.3
33	-1.6	16	14.2
34	-1.1	16	9.3
35	-1.0	3	1.7
36	-1.1	16	9.8
37	-1.1	17	[illegible]

TETRA TECH INC.
PASADENA, CALIF.

SUBJECT: BLUFF SAND CONTRIBUTION
COEN ROAD TO VERMILION

COMPUTED: PEG   CHECKED:

PROJECT: A
FILE NO:
DATE: PAGE 2 OF 3 PAGES

PROFILE	BLUFF ER	BLUFF HEIGHT	BLUFF SAND CONTRIBUTION
38	-0.9 Ft/YR	18'	9
39	-1.0	19	10.6
40	-0.9	20	10.0
41	-0.6	20	6.7
42	-0.8	20	8.9
43	-0.9	20	10.0
44	-0.9	20	10.0
45	-1.0	20	11.1
46	-0.9	20	10.0
47	-0.7	21	8.2
48	-0.6	21	7.0
49	-0.4	21	4.7
50	-0.5	21	5.3
51	-0.7	21	8.2
52	-0.7	22	8.6
53	-1.1	23	14.1
54	-1.2	24	16.0
55	-1.1	23	14.1
56	-0.9	23	11.5
57	-0.7	22	8.6
58	-0.5	21	5.8
59	-0.3	20	3.3
60	-0.1	19	1.1
61	0	18	0
62	0	13	0
63	-0.2	1	0.1
64	-0.5	7	1.9
65	-0.3	15	2.5
66	0	22	0
67	-0.2	21	2.3
68	0	21	0
69	0	20	0
70	0	20	0
71	0	19	0
72	0	19	0
73	0	19	0
74	0	16	0

TETRA TECH INC.
PASADENA, CALIF.

SUBJECT: BLUFF SAND CONTRIBUTION
COEN ROAD TO VERMILION
COMPUTED: PEG CHECKED:
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PROFILE	BLUFF EROSION RATE (FT/YR)	BLUFF HEIGHT (FT)	BLUFF SAND CONTRIBUTION (C.Y.)
75	0	16	0
76	-0.1	21	1.2
77	-0.3	21	3.5
78	-0.2	21	2.3
79	-0.4	20	4.4
80	-0.4	20	4.4
81	0	16	0
82	0	8	0
83	0	8	0
84	0	7	0
85	0	6	0
86	0	5	0
87	0	5	0
88	0	1	0

TOTAL YEARLY INPUT: 663.5 C.Y.

(1) BLUFF EROSION RATE FROM OHIO DEPT. OF NATURAL RESOURCES DATA, 1877-1973

(2) BLUFF HEIGHT COMPUTED FROM GROUND SURVEY AND STEREOGRAPHIC AERIAL PHOTOS.

(3) SAND CONTRIBUTION IN ERODED BLUFF = 15% OF ERODED VOLUME.

TETRA TECH INC. PASADENA, CALIF.	SUBJECT Condition No. 1 Bluff Position COMPUTED PEG. CHECKED	PROJECT Appendix B FILE NO DATE PAGE OF PAGES

Condition No. 1 : No Piers or Protective Structures

1) Begin with 1973 Bluffline (from Photos)

2) Advance to 1837 Bluffline using long-term erosion rate* multiplied by 136 years,

3) Move shoreward a distance of 136 feet (1.0† feet/year x 136 yrs.) from 1837 bluff to 1973 "natural" position.

4) For 2023 A.D. bluff position, move shoreward from 1973 "natural" position a distance of 50 feet (1.0 feet/year x 50 years).

*Long-term erosion rate generated from Ohio Dept. of Natural Resources data spanning 1877-1973.

† Erosion rate of 1.0 feet/year is assumed for "natural" bluff of Lake Erie if man-made structures were not present.

① Profile No	② Long-Term Erosion Rate, ODNR (ft/yr).	③ 1837 Bluff 1973 Position + 136 yrs.	④ 1973 Bluff 1837 Position − 136 feet	⑤ 2023 A.D. Bluff 1973 Position − 50 feet
1	−0.7	+95	−41	−91
2	−0.9	122	−14	−64
3	−1.1	150	+14	−36
4	−1.1	150	+14	−36
5	−1.1	150	+14	−36
6	−1.3	177	+41	−9
7	−1.7	231	+95	+45
8	−1.7	231	+95	+45
9	−1.7	231	+95	+45
10	−1.6	218	+82	+32

TETRA TECH INC.
PASADENA, CALIF.

SUBJECT: CONDITION No. 1
BLUFF POSITION

COMPUTED: PEG. CHECKED:

PROJECT: B
FILE NO:
DATE: PAGE 2 OF 3 PAGES

PROFILE No.	LONG-TERM EROSION RATE	1837 BLUFF	1973 BLUFF	2023 A.D. BLUFF
11.	-1.3	+177	+41	-9
12	1.0	136	0	-50
13	1.3	177	+41	-9
14	1.5	204	+68	+18
15	1.8	245	109	+59
16	2.0	272	136	+86
17	1.9	258	122	+72
18	1.5	204	68	+18
19	1.4	190	54	+4
20	1.3	177	41	-9
21	1.4	190	54	+4
22	1.6	218	82	+32
23	1.6	218	82	+32
24	0.9	122	-14	-64
25	1.0	136	0	-50
26	1.2	163	+27	-23
27	1.4	190	54	+4
28	1.2	163	+27	-23
29	0.8	109	-27	-77
30	1.2	163	+27	-23
31	1.4	190	54	+4
32	1.3	177	41	-9
33	1.6	218	82	+32
34	1.1	150	14	-36
35	1.0	136	0	-50
36	1.1	150	+14	-36
37	1.1	150	+14	-36
38	0.9	122	-14	-64
39	1.0	136	0	-50
40	0.9	122	-14	-64
41	0.6	82	-54	-104
42	0.8	109	-27	-77
43	0.9	122	-14	-64
44	0.9	122	-14	-64

TETRA TECH INC. PASADENA, CALIF.	SUBJECT: CONDITION No. 1 BLUFF POSITION	PROJECT: B
	COMPUTED: PEG. CHECKED:	FILE NO:
		DATE: PAGE 3 OF 3 PAGES

PROFILE No.	LONG-TERM EROSION RATE	1837 BLUFF	1973 BLUFF	2023 A.D. BLUFF
45	-1.0	136	0	-50
46	0.9	122	-14	-64
47	0.7	95	-41	-91
48	0.6	82	-54	-104
49	0.5	68	-68	-118
50	0.7	95	-41	-91
51	0.7	95	-41	-91
52	1.1	150	+14	-36
53	1.2	163	+27	-23
54	1.1	150	+14	-36
55	0.9	122	-14	-64
56	0.7	95	-41	-91
57	0.5	68	-68	-118
58	0.3	41	-95	-145
59	0.1	14	-122	-172
60	0	0	-136	-186
61	0	0	-136	-186
62	0.2	27	-109	-159
63	0.5	68	-68	-118
64	0.3	41	-95	-145
•				
•				
•				
•				
•				
88				

1837 BLUFF POSITION FOR THIS REACH IS BASED ON VERMILION MAP. POSITIONS OF 1973 AND 2023 A.D. BLUFFS ASSUME NATURAL RECESSION OF THESE BLUFFS TO BE 136 AND 186 FEET, RESPECTIVELY.

NOTE: ALL BLUFF POSITIONS ARE GIVEN RELATIVE TO ACTUAL 1973 BLUFF. PLUS (+) SIGN DENOTES A POSITION LAKEWARD OF THE 1973 BLUFF AND A MINUS (-) SIGN DENOTES SHOREWARD DISPLACEMENT.

TETRA TECH INC. PASADENA, CALIF.	SUBJECT CONDITION No. 2 & No. 3 BLUFF POSITION	PROJECT APPENDIX C
	COMPUTED PEG. CHECKED	FILE NO
		DATE PAGE 1 OF 4 PAGES

CONDITION No. 2 : HARBOR PIERS AND ATTENDENT SHORE PROTECTION STRUCTURES

1) BEGIN WITH 1973 BLUFF (FROM PHOTOS) AND 1837 BLUFF (DERIVED FOR CONDITION NO. 1).

2) FROM 1973 BLUFF (ACTUAL), PROCEED LANDWARD A DISTANCE EQUAL TO 50 YEARS MULTIPLIED BY THE LONG-TERM EROSION RATE DEVELOPED BY THE OHIO DEPARTMENT OF NATURAL RESOURCES DATA. THIS YIELDS THE PREDICTED POSITION OF THE 2023 A.D. BLUFF.

PROFILE No.	LONG-TERM EROSION RATE (FT/YR).	2023 A.D BLUFF
6	-1.3	-65
7	1.7	85
8	1.7	85
9	1.7	85
10	1.6	80
11	1.3	65
12	1.0	50
13	1.3	65
14	1.5	75
15	1.8	90
16	2.0	100
17	1.9	95
18	1.5	75
19	1.4	70
20	1.3	65
21	1.4	70
22	1.6	80
23	1.6	80
24	0.9	45

TETRA TECH INC. PASADENA, CALIF.	SUBJECT CONDITION No. 2 BLUFF POSITION	PROJECT C
	COMPUTED D.G. CHECKED	FILE NO
		DATE PAGE 2 OF 4 PAGES

PROFILE No.	LONG-TERM EROSION RATE	2023 A.D. BLUFF
25	1.0	-50
26	1.2	60
27	1.4	70
28	1.2	60
29	0.8	40
30	1.2	60
31	1.4	70
32	1.3	65
33	1.6	80
34	1.1	55
35	1.0	50
36	1.1	55
37	1.1	55
38	0.9	45
39	1.0	50
40	0.9	45
41	0.6	30
42	0.8	40
43	0.9	45
44	0.9	45
45	1.0	50
46	0.9	45
47	0.7	35
48	0.6	30
49	0.5	25
50	0.7	35
51	0.7	35
52	1.1	55
53	1.2	60
54	1.1	55
55	0.9	45
56	0.7	35
57	0.5	25
58	0.3	15

TETRA TECH INC.
PASADENA, CALIF.

SUBJECT CONDITION No. 2 & No. 3
BLUFF POSITION

COMPUTED PEG. CHECKED

PROJECT C
FILE NO

DATE PAGE 3 OF 4 PAGES

PROFILE NO.	LONG-TERM EROSION RATE	2023 A.D. BLUFF
59	-0.1	5
60	0	0
61	0	0
62	0.2	10
63	0.5	25
64	0.3	15
65	0.3	15
66	0.2	10
67	0	0
68	0	0
69	0	0
70	0	0
71	0	0
72	0	0
73	0	0
74	0	0
75	0	0
76	0.1	5
77	0.3	15
78	0.2	10
79	0.4	20
80	0.4	20
81	0	0
82	0	0
83	0	0
84	0	0
85	0	0
86	0	0
87	0	0
88	0	0

TETRA TECH INC. PASADENA, CALIF	SUBJECT Condition No.2 & No.3 Bluff Position	PROJECT C
	COMPUTED PEG, CHECKED	FILE NO
		DATE PAGE 4 OF 4 PAGES

CONDITION NO. 3 : EXISTING HARBOR STRUCTURES PLUS PRIVATE SHORE PROTECTION WORKS

THE EFFECT OF THE OFFSHORE BREAKWATER IS THE ONLY EFFECT TO BE ADDED TO CONDITION NO. 2 TO PRODUCE THE TOTAL EFFECT OF CONDITION NO. 3.

DATA COLLECTED DURING THE COURSE OF THIS STUDY (FIGURE , FOR EXAMPLE), SHOWS THAT THE OFFSHORE BREAKWATER HAS HAD NO IDENTIFIABLE EFFECT ON SHORE STABILITY ALONG THE STUDY REACH. THEREFORE, SHORE LOSSES ASSOCIATED WITH CONDITION NO. 3 ARE CONSIDERED TO BE IDENTICAL TO THOSE OF CONDITION NO. 2.

CONDITION No. 2 : HARBOR PIER STRUCTURES + EXISTING SHORE PROTECTION WORKS

CONDITION No. 3 : HARBOR PIERS, DETACHED BREAKWATER, + EXISTING SHORE PROTECTION WORKS

RESIDENTIAL PROFILES: #19-78
#85-88

PROFILE No.	BLUFF RECESSION TO 2023 A.D. (R_i)
19	70'
20	65
21	70
22	80
23	80
24	45
25	50
26	60
27	70
28	60
29	40
30	60
31	70
32	65
33	80
34	55
35	50
36	55
37	55
38	45
39	50
40	45

TETRA TECH INC.
PASADENA, CALIF.

SUBJECT Expected Losses
Conditions No. 2 & 3 (cont.)
COMPUTED PEG CHECKED

PROJECT D
FILE NO
DATE PAGE 2 OF 8 PAGES

Profile No.	Bluff Recession to 2023 AD (R_i)
41	-30
42	40
43	45
44	45
45	50
46	45
47	35
48	30
49	25
50	35
51	35
52	55
53	60
54	55
55	45
56	35
57	25
58	15
59	5
60	0
61	0
62	10
63	25
64	15
65	15
66	10
67-75	0
76	5
77	15
78	10

$$\text{Total Loss} = \sum_{i=19}^{77} \frac{R_i + R_{i+1}}{2} \cdot 100 \frac{\text{Ft}}{\text{profile}} = 209{,}500 \text{ SF} = 4.81 \text{ Acres}$$

TETRA TECH INC.
PASADENA, CALIF.

SUBJECT: EXPECTED RECREATIONAL LAND LOSSES, CONDITIONS 2 & 3

COMPUTED: PEG. CHECKED:

PROJECT: D

FILE NO:

DATE:

CONDITION NO 2, CONDITION NO. 3.

RECREATIONAL ACREAGE LOSS TO 2023 A.D

SHERON PARK (PROFILES 6–18)

PROFILE NO.	BLUFF RECESSION TO 2023 A.D. (R_i)
6	65'
7	85
8	85
9	85
10	50
11	55
12	50
13	65
14	75
15	90
16	100
17	95
18	75

$$\text{TOTAL LOSS} = \sum_{i=6}^{17} \frac{R_i + R_{i+1}}{2} \cdot 100 \frac{ft}{profile} = 94\,500 \text{ SF} = 2.17 \text{ ACRES}$$

VERMILION CITY BEACH, MARITIME MUSEUM PROPERTY (PROFILES 79–84)

79	20
80	20
81	0
82	0
83	0
84	0

$$\text{TOTAL LOSS} = \sum_{i=78}^{83} \frac{R_i + R_{i+1}}{2} \cdot 100 \frac{ft}{profile} = 3000 \text{SF} = 0.069 \text{ ACRES}$$

TETRA TECH INC. PASADENA, CALIF.	SUBJECT EXPECTED RECREATIONAL LAND LOSSES, CONDITIONS 2 & 3	PROJECT D
	COMPUTED PEG CHECKED	FILE NO
		DATE PAGE 4 OF 8 PAGES

TOTAL RECREATIONAL LAND LOSS TO 2023 A.D. :

	SUB-TOTAL	AVE. ANNUAL
SHELDON PARK	94,500 SF	1890
VERMILION CITY BEACH / MUSEUM PROPERTY	3,000 SF	60
TOTAL =	97,500 SF	1950 SF/YEAR

AVERAGE ANNUAL LOSS = $\frac{98,500 \text{ SF}}{50 \text{ YRS}}$ = 1,950 SF/YEAR

APPENDIX E

Vermilion Harbor, Ohio Section 111 Study

Development of alternatives to mitigate damages of shoreline erosion west of Vermilion Harbor caused by federal navigation structures

Possible alternatives :

① non-structural solution - a beach restoration program in conjunction with an annual beach nourishment program; the purpose being to restore a portion of beach lost to erosion and an attempt to maintain this small protective beach by nourishment;

② structural solution - similar to the non-structural solution above except the restored and nourished beach is maintained by a series of short groins;

③ structural solution - control of erosion by revetment of entire stretch of shoreline influenced by the federal navigation works.

Features common to each alternative :

① In the first two alternatives mentioned above a source of "suitable" beach material is needed for both the restoration and nourishment phases. There are three possible sources in the Vermilion area:
A) material bypassed from the fillet East of the Vermilion East Pier
B) material dredged from the harbor approach channels as part of the normal harbor maintenance
C) material brought in from an outside source either dredged from the lake and barged in or trucked in from a local quarry.

The material in the East Pier fillet is being considered as a sand source for a back-pass program to protect the Linwood Beach area further East. Even this plan may not be implemented if the proper easements cannot be obtained from the Lagoon Beach residents to remove accumulated land fronting their property. This rules out source A for the present.

Source B materials have been declared unlikely sources for beach materials in recent (July 1978 and October 1979) surveys by the Corps of Engineers, in samples taken from the harbor approach channels, or from the harbor itself

Development of alternatives for erosion mitigation (contd)

the Corps has found that the dredged material to be predominately fines, which would require extensive reworking to remove suitable beach material, or that the samples were polluted which would prohibit even open lake disposal.

Source C is therefore the only remaining viable source of restoration and nourishment material. Estimates requiring suitable beach materials will therefore assume outside sources for calculation purposes.

(2) In the two mitigation alternatives requiring beach restoration and nourishment, appropriate measures must be taken to limit the transport of placed material into the City Beach / Museum area by incident waves from the westerly quadrants. The present offshore detached breakwater creates a shadow zone in this area, preventing waves from easterly quadrants from redistributing this material to the west. The restored beach material and subsequent nourishment material would be transported into this shadow zone where it would be very stable thus defeating the purpose of the nourishment program. In order to prevent this easterly movement into the shadow zone, a groin would be constructed at a point West of the West Pier out of the shadow of the offshore breakwater. This groin would compartmentalize the beach east of it up to the pier forming a stable pocket beach. Whereas, material placed immediately west of this groin will be prevented from moving to the east but will be available for transport to the west by wave action. In the case of the third alternative suggested above this same groin compartmentalizes the City Beach/Museum area protecting it from future shoreline movements or erosion and saves additional expense of reveting this portion of the shoreline.

The possibility of constructing a groin fronting the Marine Museum west of Vermilion harbor has been coordinated with the Ohio Department of Natural Resources. As a result of contact with the Chief Engineer's office ODNR, it has been determined that they have no present or future plans to protect the museum with offshore works; therefore there is no conflict with the proposed groin.

Vermilion Harbor, Ohio Section 111 Study

Purpose, Location and Orientation of Proposed Groin

Purpose: As stated above, the main purpose of the proposed groin is to prevent nourishment material from being transported to the east where it would be lost from the littoral system. As such it is felt that this groin is a necessary part of the Federal responsibility for mitigation in that it limits to the minimum the amount of nourishment needed to fullfil the purpose.

Location: The location of the groin was determined using the following considerations:

- as shown on figure E-1 on the following page, unrefracted wave incidence angles from the north-northeast through east-northeast are shielded by the offshore detached breakwater for a distance of approximately 1000 feet west of the west pier.
- on figure 15 of the May 1978 Stanley Report the ranges in shoreline equilibrium before and after the breakwater construction show no significant change west of Stanley's station 10+00 W or 800 feet west of the west pier.
- the angle of the shoreline on either side of a point 1000 feet west of the west pier is such that waves approaching from the northeast, north-northeast, and north have an onshore or slight westward component of wave energy in the area east of this point; but a strong westerly component of wave energy west of this point [reference figures 17, 18, and 19 of the Stanley Report May 1978.]

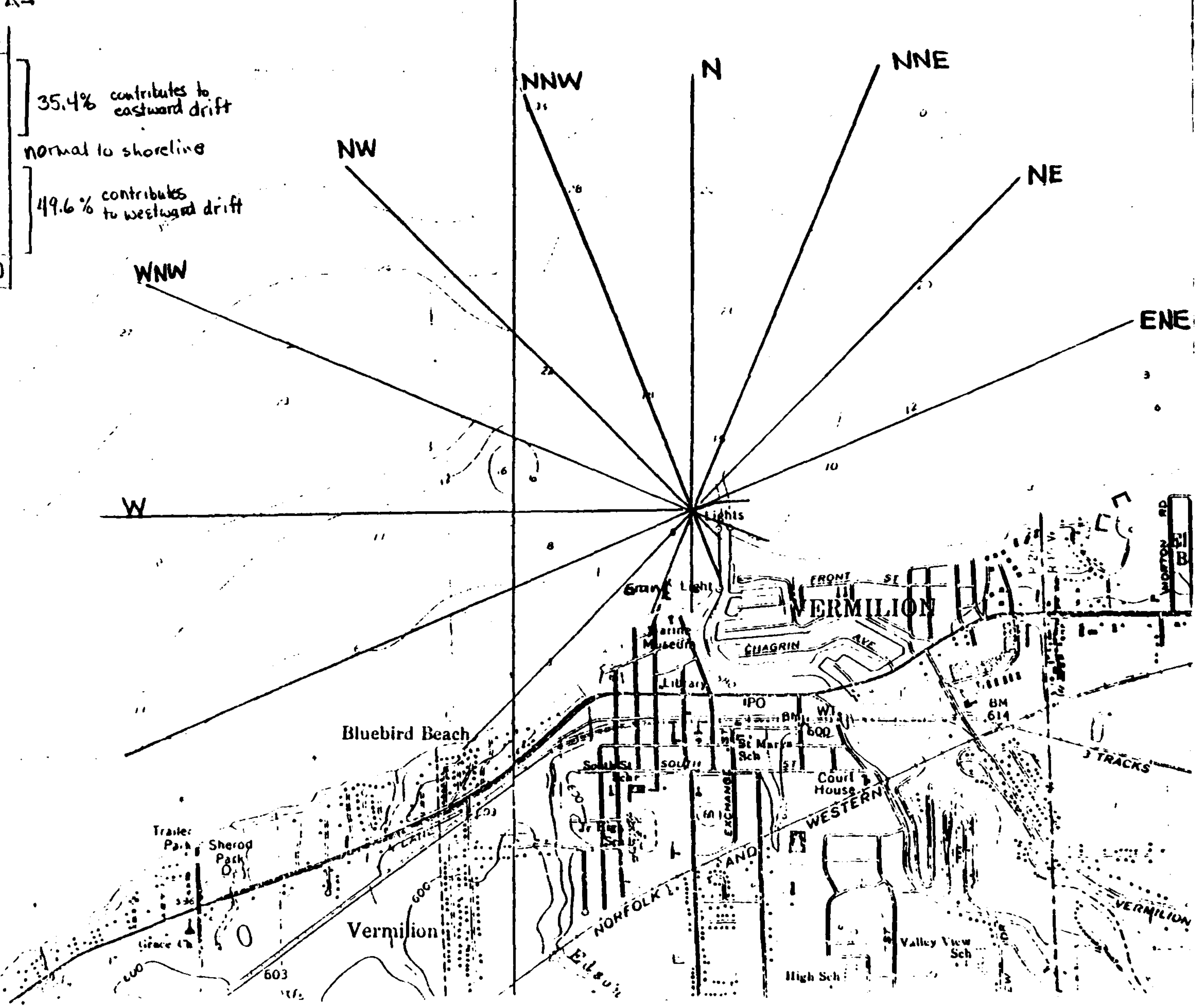
These considerations suggest a location for the groin about 1000 feet west of the west pier, which coincides with the east side of the lakeward extension of Washington Street. This would be the optimum location for a groin in that this point of land is a slight promontory having been hardpointed in the past.

Another consideration, however, prevails. That is the location of the groin on public vs. private property. In communications with Mayor Johnson of the City of Vermilion it was found that this proposed location for the groin was impracticable because the land at the foot of Washington Street was private property. The distribution of public vs private property west of the west pier is shown on figure E-2. To locate the groin entirely on public property it must be located such that its westernmost toe is 70 feet east of the foot of Washington St. extended to the lake.

Average of TM37 and LCD data from Stanley Report Table A1 pg A4

	TM37	LCD	Aver.	
W	8.3	10.5	9.4	35.4% contributes to eastward drift
WNW	15.9	11.2	13.5	
NW	13.0	11.9	12.5	
NNW	16.2	13.7	15.0	normal to shoreline
N	14.9	16.5	15.7	49.6% contributes to westward drift
NNE	19.1	17.3	18.2	
NE	10.4	11.7	11.0	
ENE	2.2	7.2	4.7	
			100.0	

PERCENT WAVE DISTRIBUTION BY DIRECTION OF ORIGIN



Scale: 1" = 2000 ft.

FIGURE: E-1

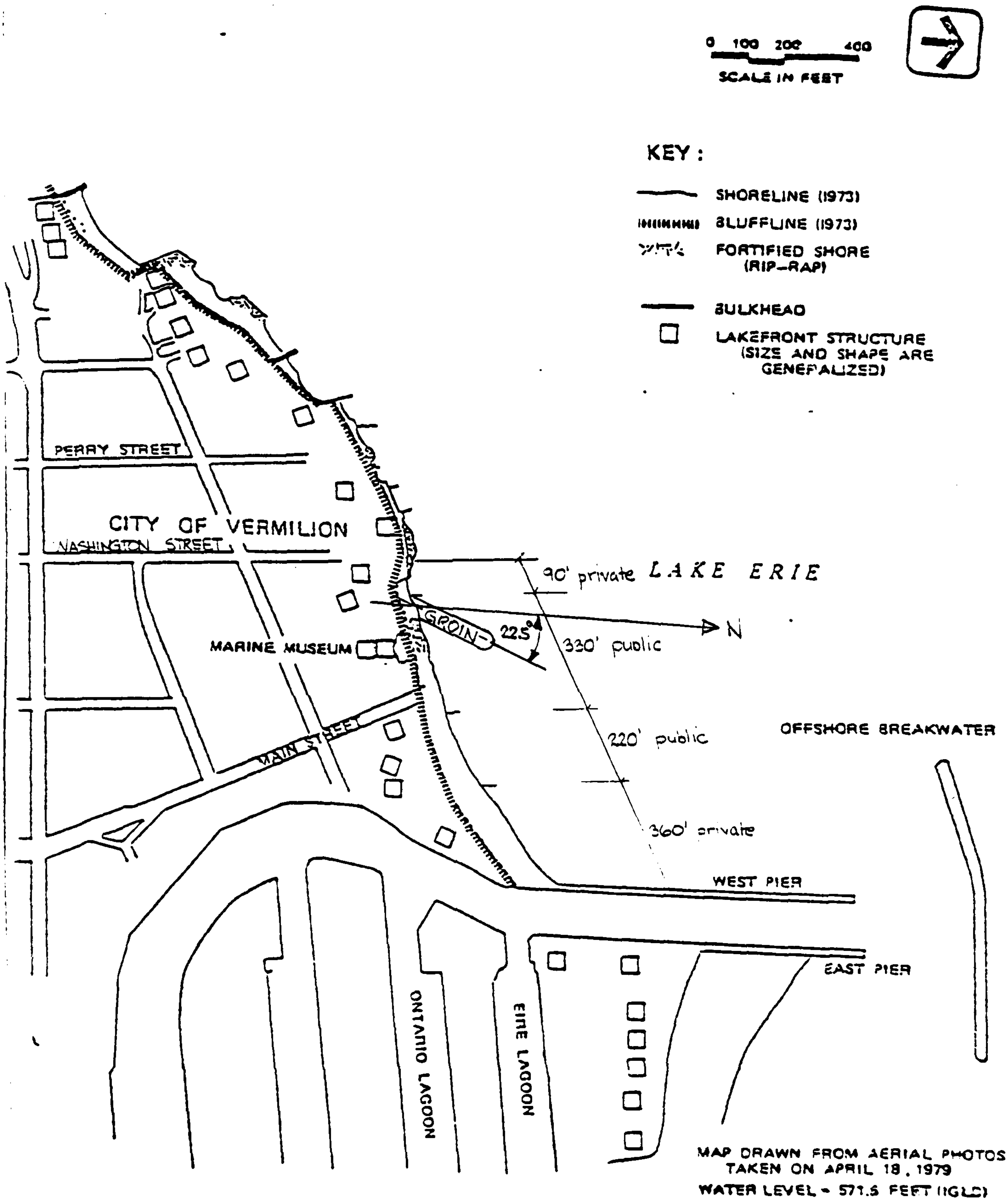


FIGURE: E-2
DISTRIBUTION OF PROPERTY 1000 ft WEST OF WEST PIER
LOCATION OF NEW GROIN FRONTING MARINE MUSEUM

- Orientation of the Groin: The orientation of the centerline of the groin should be alligned with the north-northeast direction of wave approach for the following reasons:
  - this allignment will provide the easiest access for waves from the north and north-northeast to distribute placed nourishment material to the shores westerly of the groin
  - this allignment will provide maximum protection to the shore fronting the Marine Museum from waves originating from the westerly quadrants.

- Length: The length of the groin at this orientation must be determined by up to date bathymetry and consideration of the amount of nourishment material which will be placed adjacent to the structure.

See figure E-2 for the most probable location and orientation of the groin in the City Beach/Marine Museum area.
This groin will hereinafter be referred to as the Marine Museum Groin.

Vermilion Harbor, Ohio Section 111 Study

Evaluation of Mitigation Alternatives

Alternative I : Beach Nourishment - **MAXIMUM** Federal Participation
a non-structural solution
major features of this alternative are :

① construction of a new groin fronting the Marine Museum at the location and orientation shown on figure E-2 ;
② beach restoration east of this groin in areas which have eroded due to the navigation structures ;
③ shoreline restoration from the groin west to Coen Road which is the assumed western limit of influence of the navigation works ; and
④ a nourishment program which will deposit on an annual basis, an amount of beach material equivalent to the annual amount of erosion attributable to the Federal Navigation Works over and above the natural erosion quantity which would occur had the navigation structures not been built.

See figure E-3 for Alternative I physical features

Feature ① Construction of new groin - Marine Museum Groin

from previous analysis and reference to figure E-2

a) the location of the groin is set : the centerline of the groin shall intersect the shoreline approximately 885 ft west of the west pier

b) the orientation of the groin centerline shall be 22.5° east of north

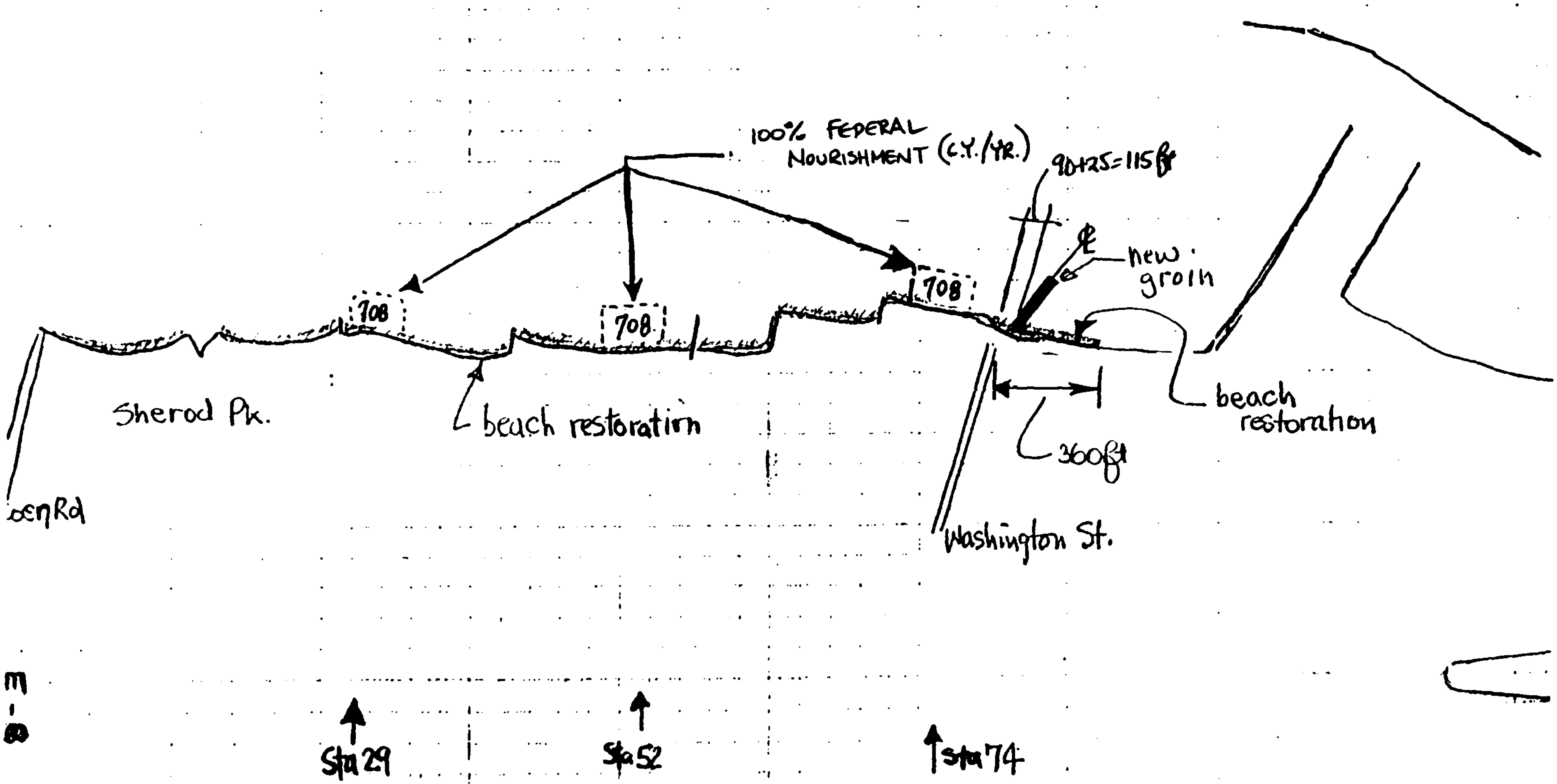
c) the length shall be determined from existing bathymetric information and the assumed amount of nourishment to be placed downdrift of the groin

The location where the groin centerline intersects the shoreline is approximately the same as where the Stanley Report profile 10+00W (figure 9 May 1978) intersects the shoreline. Therefore this Stanley profile was adjusted 22.5° from North to North-east and used as the assumed bathymetry along the groin centerline.

A 100 foot wide beach at Mean Lake Stage was assumed for a downdrift profile to account for containment of nourishment material. See figure E-4 for the Assumed Groin Profile.

MAJOR FEATURES:

1. 20-FOOT WIDE BEACH RESTORATION (EXCEPT 500' ADJACENT TO WEST PIER).
2. MUSEUM GROIN
3. BEACH REPLENISHMENT AT THREE SITES



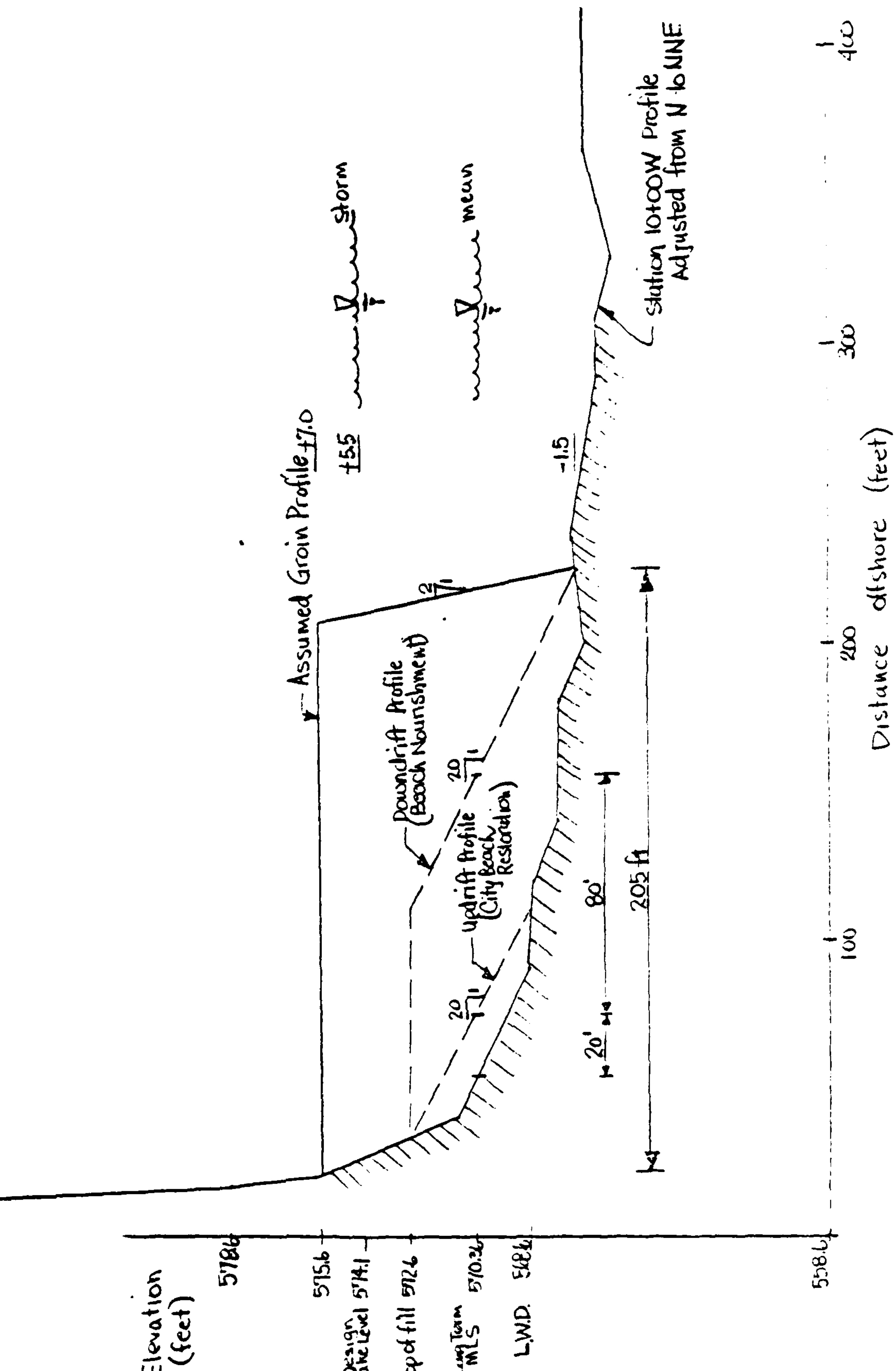
BEACH NOURISHMENT - MAXIMUM Federal Participation

Figure E-3 Mitigation Alternative I

Vermilion Harbor, Ohio   Section 111 Study

Marine Museum Groin Estimated Length

Figure E-4: Bottom Profile NNE of Stanley Station 10+00W and Assumed Groin Profile



Vermilion Harbor, Ohio   Section 111 Study

Marine Museum Groin - Preliminary Design

assuming that the beach nourishment fill placed west of the groin will control design length of the groin

also assume that this nourishment fill will only extend out into the lake 100 ft at elevation 570.36 (long term MLS) and the fill will take on a 1:20 slope when placed

figure -4 shows where this fill will intersect the bottom profile. this sets the location of the toe of groin at 205 ft seaward of the bluff intersection with the groin profile

— if the design lake level of 574.1 IGLD (+5.5) from the Lakeview Park Design is used as the storm water level

set the top of groin elevation at 575.6 IGLD (+7.0)
this is 5.24 ft above long term mean lake stage
and it is 1.50 ft above the storm lake design level
this allows some overtopping of waves but prevents beach material movement with top of fill at 572.6

from Table 1 section 2.3.1 of this report, deepwater wave characteristics at Vermilion, the longest period waves which can be expected at this site are 8.0 seconds from Northeast
7.5 seconds from Northwest
— using 8.0 seconds for conservatism

d_s = depth of water at toe of structure = 7.0 ft

$$\frac{d_s}{gT^2} = \frac{7.0}{32.2(8)^2} = 0.0034$$

m = nearshore slope = approximately 1:200 from Stanley profiles
m = 0.005

from figure 7-4 pg 7-9 of Shore Protection Manual

$H_b/d_s = 0.82$ $H_b = .82(7.0) = 5.74$ Design Breaker Height = 5.75 ft

Note: Examination of the design wave was also performed utilizing guidance from a draft CERC report on the shoaling and refraction of irregular waves as they approach the shore from various angles. The results of this analysis indicate that the design wave height presented above using monochromatic wave theory is slightly conservative and will therefore be used in this design.

Marine Museum Groin - Preliminary Design

Assuming a rubble mound groin with 1:2 side slopes
Armor layer design from equation 7-105 to 7-125 of SPM

Weight of armor units $W = \dfrac{w_r H^3}{K_D (S_r - 1)^3 \cot\theta}$

where: $w_r = 160$ lb/ft³
$H = 5.75$ ft
$S_r = 2.56$
$w_w = 62.4$ lb/ft³
$\cot\theta = 2$
K_D = stability coefficient
for rough angular units
placed randomly in 2 stone layers i.e. $n = 2$
$\cot\theta = 2$ slope of face
breaking wave condition on head
$K_D = 2.5$
$K_D = 3.5$ for trunk breaking wave condition
for no damage criteria

Note: w_r in Lakeview Park Design varied from 150 to 175 lb/ft³ for locally available armor stone. 160 lb/ft³ is used here as a median value

$W = \dfrac{160 (5.75)^3}{2.5 (2.56-1)^3 (2)} = 1600$ lbs for head $\underline{W = 1600 \text{ lbs}}$

size variation allowed 0.9W to 2.0W or $\underline{1450 \text{ lbs to } 3200 \text{ lbs}}$ units
mean = 2325

$W = (1600) \dfrac{2.5}{3.5} \approx 1150$ lbs for trunk $\underline{W = 1150 \text{ lbs}}$

size variation allowed 0.9W to 2.0W or $\underline{1050 \text{ lbs to } 2300 \text{ lbs}}$ units
mean = 1675

First underlayer (core) Stone size varies from 0.06W to 0.2W

Underlayer Stone Size varies $\underline{96 \text{ lbs to } 320 \text{ lbs}}$

Bedding stone (blanket) Stone size varies from 0.00015W to 0.01W

Bedding Stone Size varies $\underline{0.25 \text{ lbs to } 16 \text{ lbs}}$

Thickness of Armor Layer: $r = n k_\Delta \left(\dfrac{W}{w_r}\right)^{1/3}$ $n = 2$ $k_\Delta = 1.15$

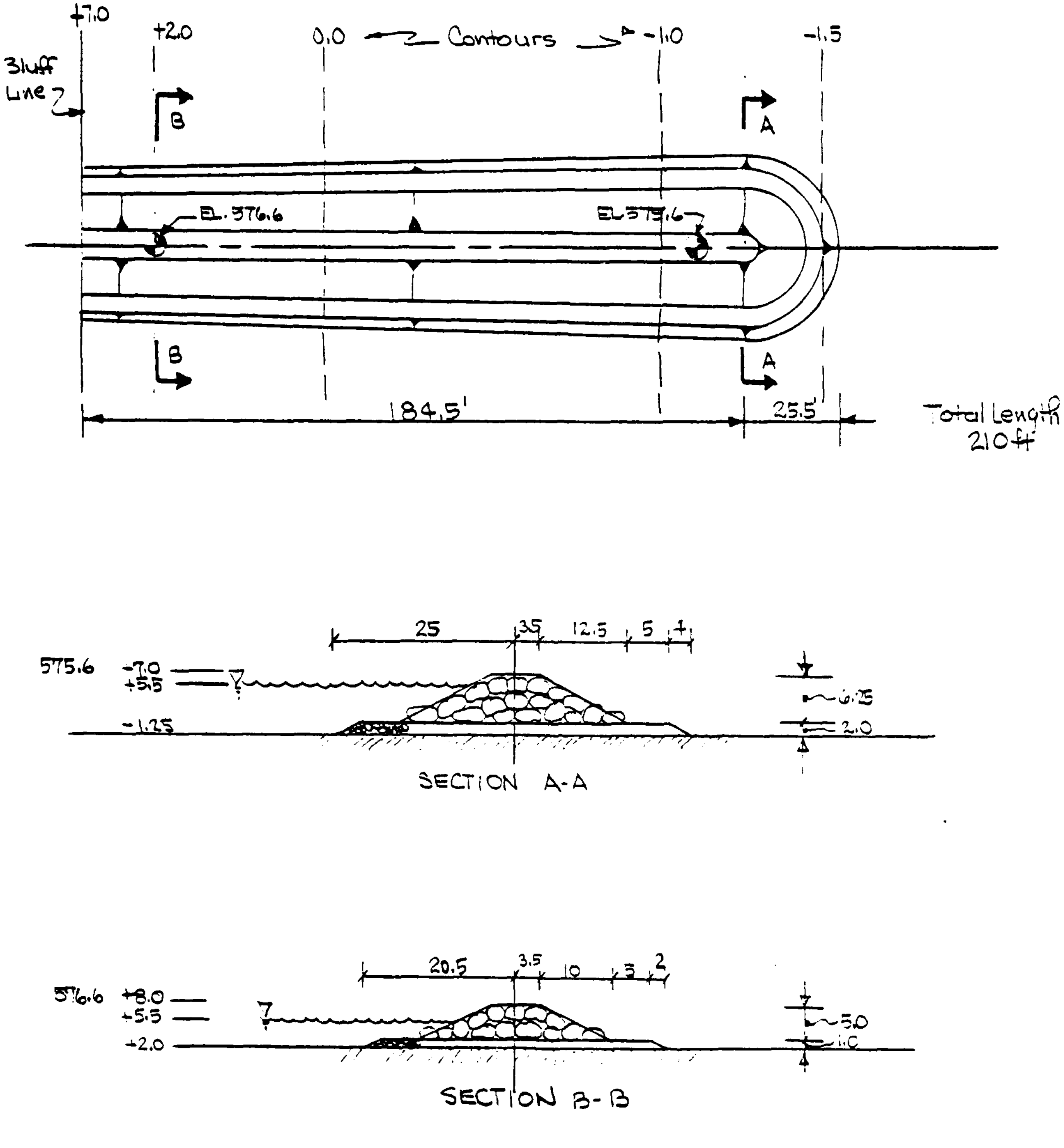
for $W = 1600$ $r = 4.96 \approx 5.0$ ft
$W = 1150$ $r = 4.44 \approx 4.5$ ft

mean size armor
for $W = 2325$ $r = 5.6$ ft
$W = 1675$ $r = 5.0$ ft

Crest Width: $B = n k_\Delta \left(\dfrac{W}{w_r}\right)^{1/3}$; $n = 3$ minimum $B = 6.66$ ft use $\underline{B = 7.0 \text{ ft}}$
Crest Elevation: 575.6 or +7.0 ft (LWD)

Vermilion Harbor Ohio Section III Study

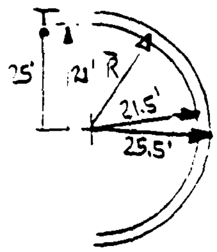
Figure E-5: MARINE MUSEUM Groin - Plan & Cross Section



Vermillion Harbor, Ohio Section 111 Study

Marine Museum Groin - Quantity Take-Offs

Blanket layer at round head

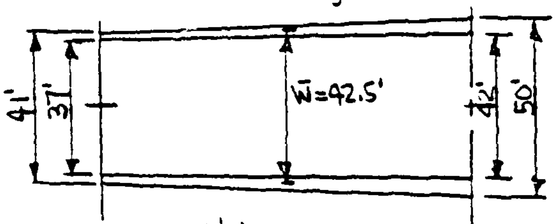


average radius to mid depth of blanket = 23.25 ft

$$\text{Area} = \frac{1}{2}\pi\bar{R}^2$$

$$\text{Volume} = (2')\,\frac{1}{2}\pi\bar{R}^2 = 1698\ ft^3 \approx 63\ yd^3$$

Blanket layer for trunk

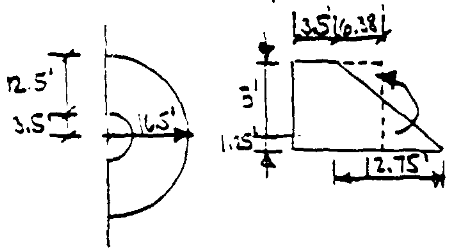


Average depth of blanket = 1.5 ft
Average width of blanket = 42.5 ft
Length = 184.5 ft
Grade blanket material from 1.0 ft thick at bluff to 2 ft thick at roundhead

$$\text{Volume} = 184.5 \times 42.5 \times 1.5 = 11{,}762\ ft^3 = 436\ yd^3$$

Total Blanket Material $\approx$ 500 yd^3

Armor layer at roundhead



find surface area a 2 stone thick volume equivalent

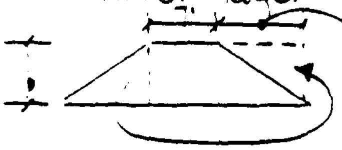
$$A = \frac{1}{2}\pi R^2 = \frac{1}{2}\pi(3.5+6.38)^2 = 153.3\ ft^2$$

number of armor units in a 6.25' layer as opposed to a 5.6 layer roughly = $\frac{6.25}{5.6} \times n$

Number of individual armor units needed $N_r = A\,n\,k_\Delta\left(1-\frac{P}{100}\right)\left(\frac{w_r}{W}\right)^{2/3}$
where $P = 37$, $k_\Delta = 1.15$, $w_r = 160$, $W = 2325$, $n = \frac{6.25}{5.6}n$

N_r = 45 units @ 2325 lbs = 104,625 lbs or 53 tons

Armor layer for trunk



Aver = $\frac{10+12.5}{2}$ = 11.25

Aver = $\frac{5+6.25}{2}$ = 5.625

Aver $n = \frac{5.625}{5}n$

Surface Area Average is
$184.5\ \left(\frac{7+11.25}{}\right) = 3367\ ft^2$

$$N_r = (3367)\ \frac{5.625}{5}(2)\,(1.15)\,(.63)\left(\frac{160}{1675}\right)^{2/3} = 1147$$

N_r trunk = 1147 units @ 1675 lbs = 1,921,225 lbs
or 960 tons

Vermilion Harbor, Ohio Section 111 Study

Feature ② Beach Restoration East of Marine Museum Groin

Length of restoration needed: referring to figure E-2 determine the length of beach between the east toe of the museum groin and the west pier. that is 1000 ft minus 90ft private property minus 50ft the width of the groin at the toe or 860 ft.
But this figure must be adjusted for the length of the beach which has accreted in recent years and therefore does not need restoration.
Figure E-6 compares the shoreline of April 1973 to May 1978 adjacent to the west pier (reference Stanley Report figure 14). This figure reveals that the shore 500 to the west of the west pier has accreted while the shore further west has eroded.
Therefore only the eroding shoreline need be restored to accomplish the purpose of mitigation or a distance of 860 - 500 = 360 ft. east of the new museum groin.

Width of restoration needed: as a nominal figure assume a beach width of 20 feet at the long term mean lake level of 570.36 (1955 IGLD)
extending at a slope parallel to existing beach slope from a berm level of +4.0 LWD (572.6 IGLD) to the intersection with the existing bottom

from Stanley Report (May 1978) figures 9 and 10 profiles through the city beach area are plotted on figure E-7
these profiles 4+00 W and 10+00 W are equivalent to approximately 200 and 800 feet west of the west pier respectively
an average city beach profile was assumed which lies between the two extremes shown by the 4+00 W and 10+00 W profiles

upon this average profile the restoration is sketched for quantity take off purposes

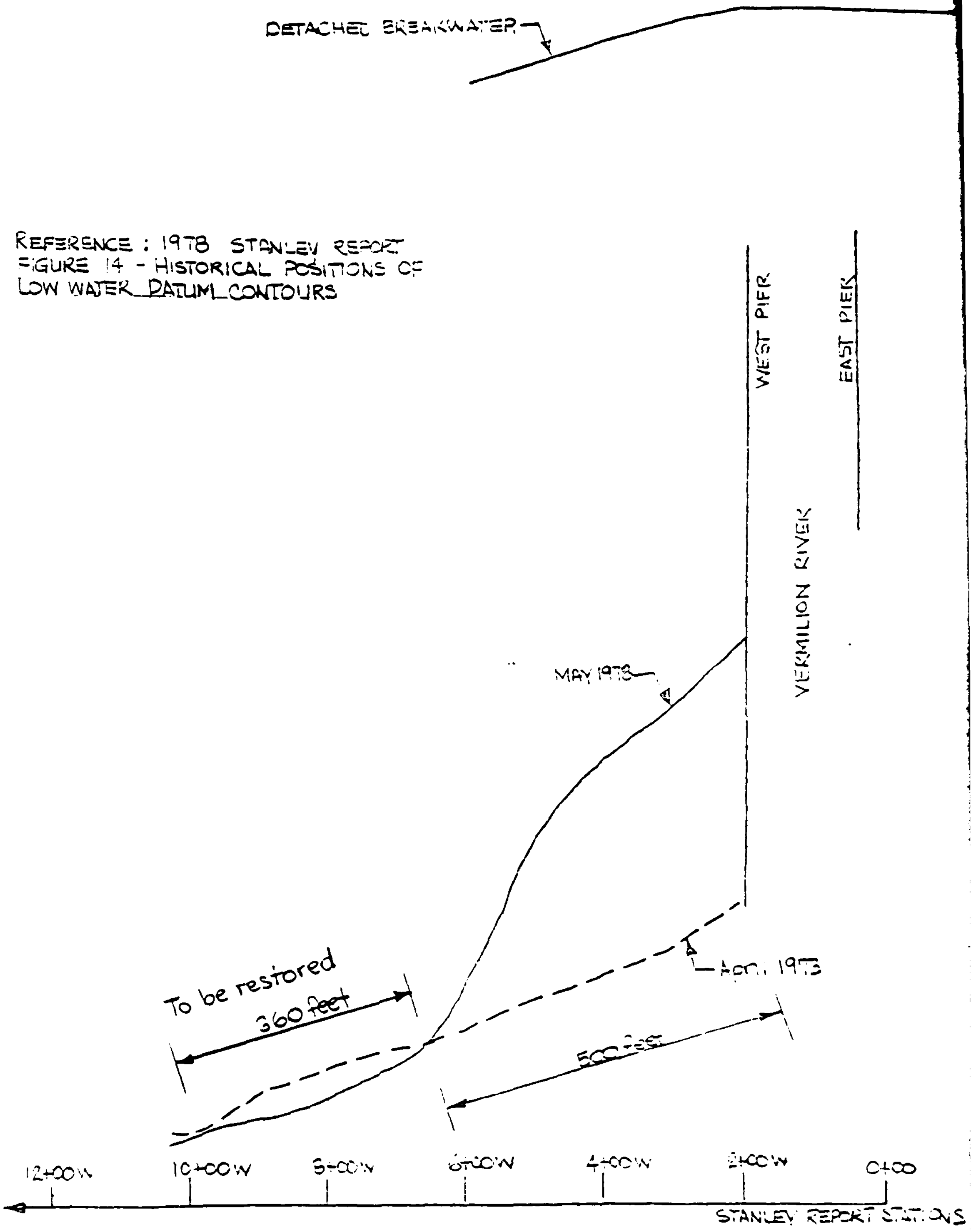


FIGURE E-6: SHORELINE COMPARISONS ADJACENT TO WEST PIER

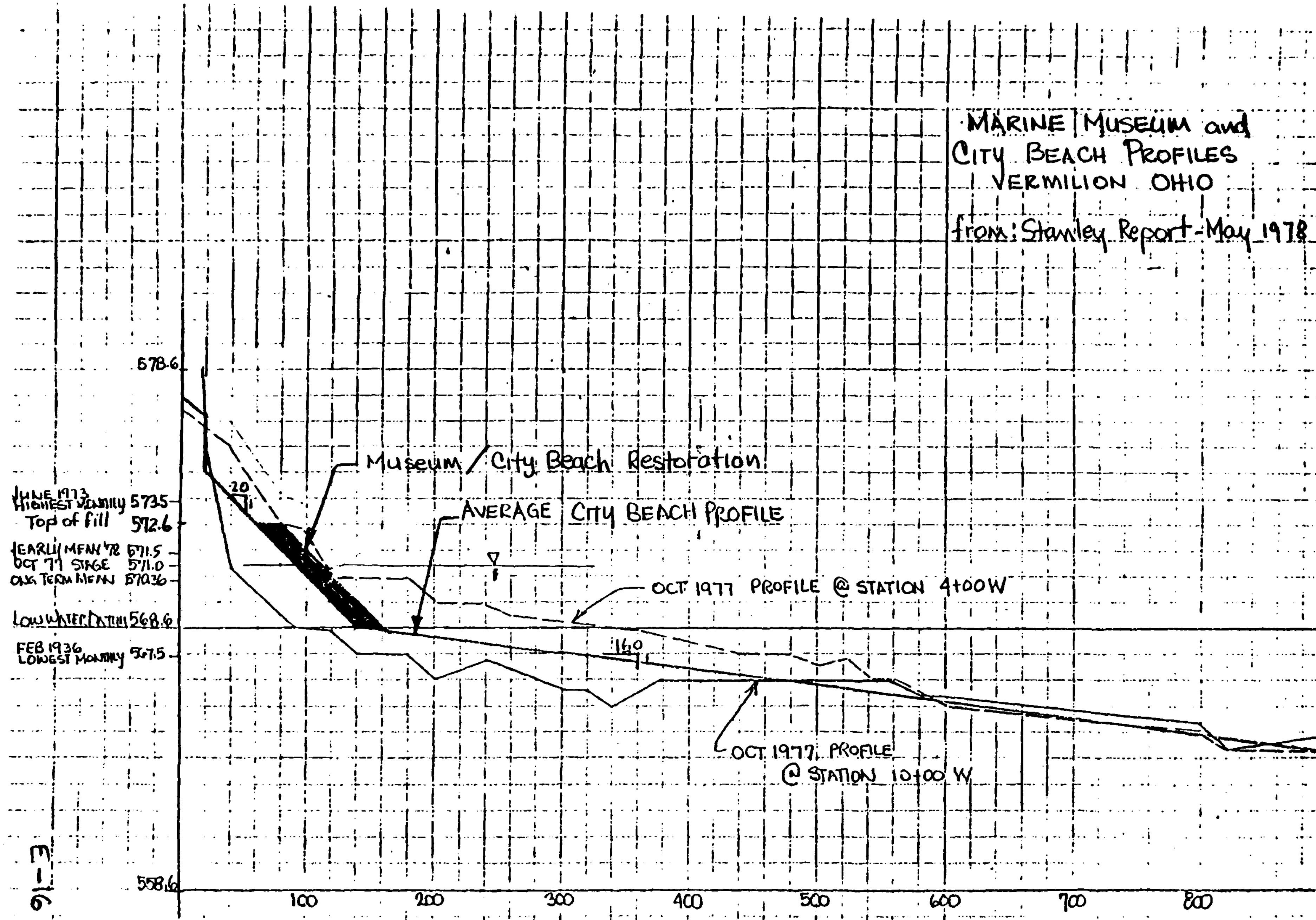
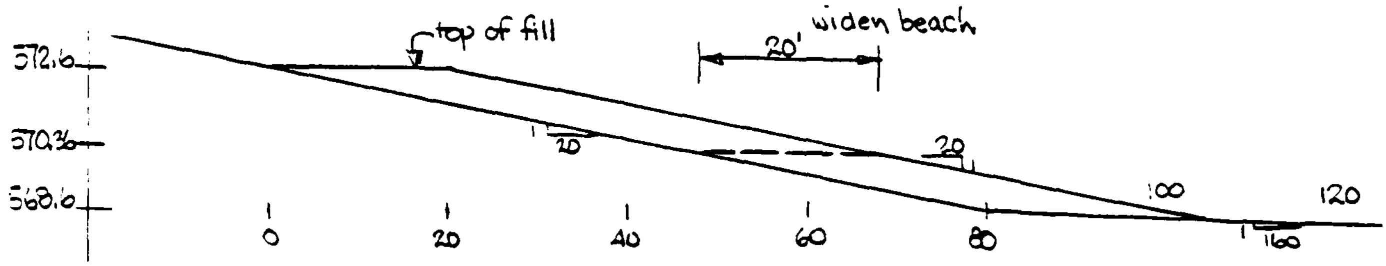


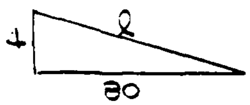
Figure E-17 Museum/City Beach Restoration Profile

Vermilion Harbor, Ohio   Section 111 Study

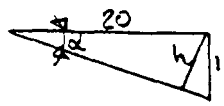
Museum / City Beach Restoration

width 20 ft at long term MLS of 570.36
slope 1:20 matching average beach slope
extent +4.0 LWD (572.6) to 0.0 LWD (568.6)





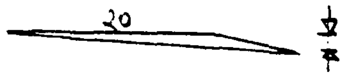
$l = \sqrt{80^2 + 4^2} = 80.1$



$\tan \alpha = \frac{1}{20}$ $\alpha = 2.86°$

$\sin \alpha = \frac{h}{20}$ $h = 0.9987$

$A = l h$
$A = 80.1 (.9987)$
$A = 80.0\ ft^2$



$A = \frac{1}{2} 20 (.15)$ $A = 1.5\ ft^2$

total Volume $= 81.5\ ft^3/ft$
$= 3.02\ yd^3/ft$

length of restoration is 360 ft
volume of restoration is $360 (3.02\ yd^3/ft) = 1087.2\ yd^3$
@ $1.512\ ton/yd^3$

Museum / City Beach Restoration = 1644 tons

Vermilion Harbor, Ohio Section 111 Study

Shoreline Restoration Museum Groin to Coen Rd.
part of Mitigation Alternative I - Feature 3

Since there are no profiles in the area west of the Marine Museum Groin except one by Stanley at their Station 22+00 W, an average profile must be assumed.

Figure E-8 shows the profile assumed using two pieces of available data

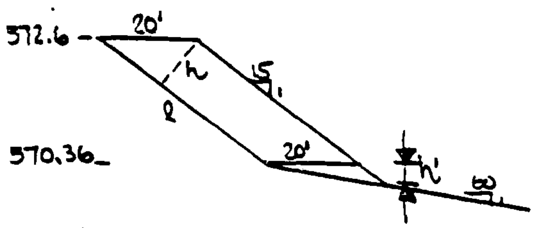
1. the Sta 22+00 W profile of Stanley adjusted to be perpendicular to the shoreline rather than north
2. the distance offshore to the 6 ft depth contour from USGS & Stanley's Charts

When more comprehensive bathymetric data is obtained profiles for specific stretches of beach could be drawn and a better estimate of beach restoration made.

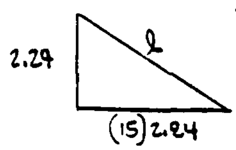
Restoration Dimensions

Length ≈ 7100 ft from Coen Road to the Marine Museum Groin
Width ≈ 20 ft at long term mean lake stage 570.36
slope 1:15 matching average beach slope
extent +4.0 LWD (572.6) to intersection with bottom

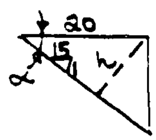
see figure E-8 on next page



$l = \sqrt{33.6^2 + 2.24^2} = 33.67$ ft.



$h' = 0.44$ ft



$\tan\alpha = \frac{1}{15}$

$\sin\alpha = \frac{h}{20}$

$h = 1.33$ ft

$$\text{Area}_{total} = lh + \tfrac{1}{2}20h'$$

$$= 33.67(1.33) + \tfrac{1}{2}20(.44) = 49.21 \text{ ft}^2$$

$$\text{Volume Total} = 49.21(7100) = 349{,}400 \text{ ft}^3 = 12{,}940 \text{ yd}^3$$

Remainder of Beach Restoration = 12,940 yd³ at 1.512 tons/yd

= 19,565 tons

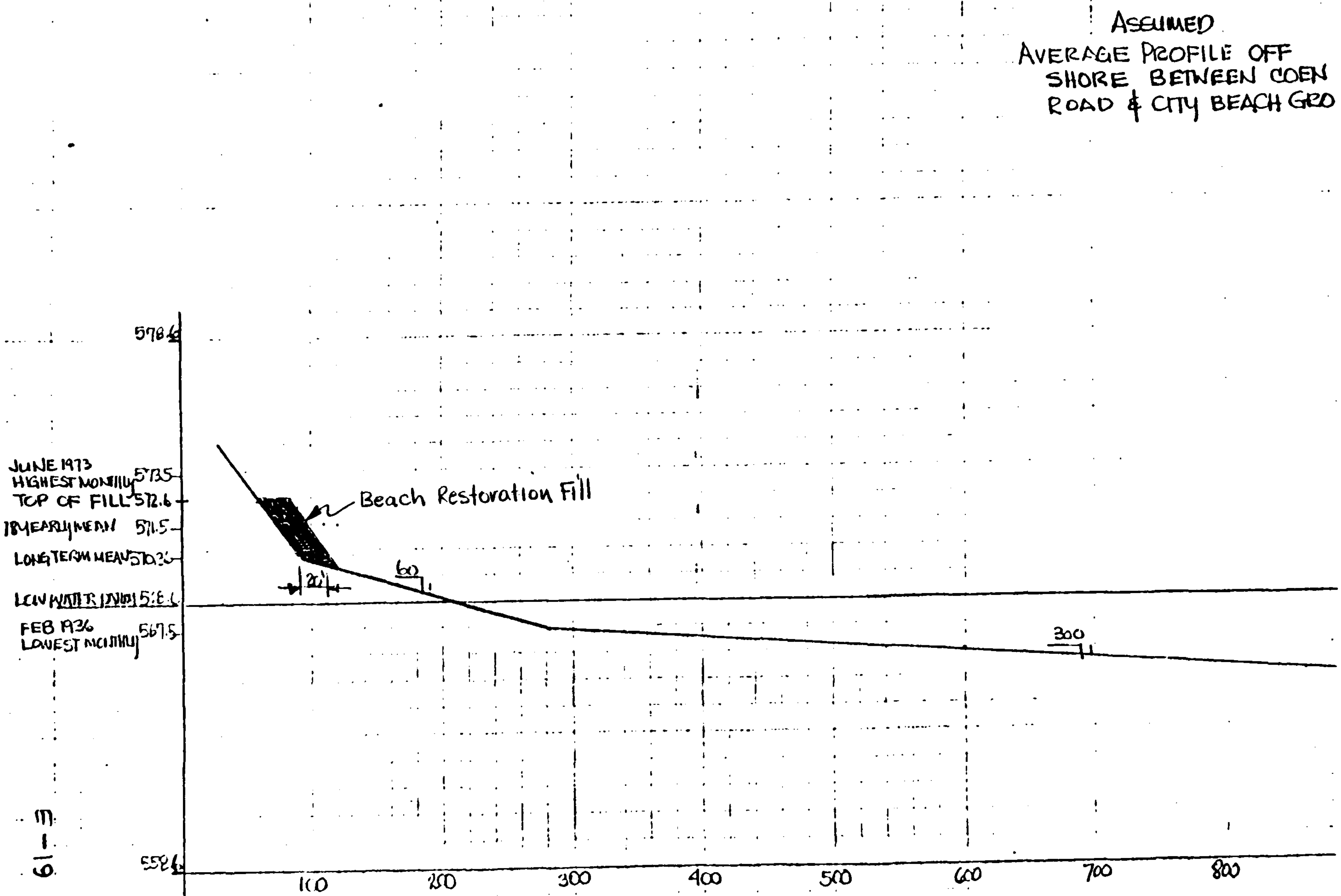


Figure E-8 : Beach Restoration Profile Museum Groin to Coen Rd.

Vermilion Harbor, Ohio   Section 111 Study

Feature (4) **MAXIMUM** Federal Participation Beach Nourishment

Based on Ohio Geological Survey Data, average annual bluff recession for areas along Lake Erie, where no man-made structures exist, is 1.0 ft/yr. This is based on about 100 years of record. If shoreline recession is considered proportionate to bluff recession, over very long periods of time, and natural berm elevation is +8 ft relative to low water datum (568.6 IGLD); and -12 ft is considered the lakeward limit of active littoral zone; then one foot of shore recession is equal to

$\frac{+8+12 \text{ ft}}{27 \text{ ft}^3/\text{yd}^3}$ or $0.741 \text{ yd}^3/\text{ft}^2$ of shoreline recession
or $0.741 \text{ yd}^3/\text{ft}^2 \times 1.0 \text{ ft/yr} = 0.741 \text{ yd}^3/\text{linear ft of shore/yr}$.

Bluff recession in Sherod Park has been quantified using 40± years of aerial photo data. The erosion rate in this stretch of unprotected shoreline (within our study limits) averages at 1.4 ft/yr recession. This equates to $1.4\,(.741) = 1.04 \text{ yd}^3/\text{ft}$ of shore/yr. by the reasoning laid out above.

If we assume pre-navigation works conditions (pre 1835), for the 7100 ft of shoreline in the study area (total 8100 ft. minus pocket beach formed by Museum Groin) natural deficiancy of supply = natural erosion rate = $0.741 \times 7100 = 5261 \text{ yd}^3/\text{yr}$. It can be reasoned that if $5261 \text{ yd}^3/\text{yr}$ were placed along this 7100 ft of shore there would have been shore stability (averaged over long time period)

However, the shore recession rate has been $1.04 \text{ yd}^3/\text{yr}/$ foot of shore as indicated by a stretch of unprotected shoreline downstream of the navigation structures. The total yardage needed to maintain shore stability at this recession rate is $1.04 \times 7100 = 7384 \text{ yd}^3/\text{yr}$

The difference $(7384 - 5261)$ or $2123 \text{ yd}^3/\text{yr}$ (29% OF TOTAL) can be attributed to the Federal Navigation works

Thus $2123 \text{ yd}^3/\text{yr}$ is the **MAXIMUM** Federal Participation amount of Beach Nourishment needed to mitigate the erosional effects of the Federal Navigation Structures

Placement: Refer to Alternative I physical features, figure **E-3** for placement of this beach nourishment. After studying the location of existing barriers to littoral drift and possible beach access points for truck haul, it was felt that breaking up the nourishment into three equal parts at approximately stations 29, 52, and 74 would best serve the purpose of natural distribution

SPG

Vermilion Harbor, Ohio Section 111 Study

Alternative I Cost/Benefit Analysis

COSTS

First Costs - features 1, 2 & 3	Quantity	Unit Price	Cost
① Marine Museum Groin Construction			
Blanket M+l 0.25 to 16 lbs	300 yd³	\$27/yd³	13500
Head Armor 1450 to 3200 lbs	53 tons	\$33/ton	1750
Trunk Armor 1050 to 2300 lbs	960 tons	\$33/ton	31680
② Museum/City Beach Restoration	1087 yd³	\$10/yd³	10870
③ Shoreline Restoration	12,940 yd³	\$10/yd³	129400
a Subtotal			187200
b Contingency @ 15% of a			28080
c Subtotal a+b			215,280
d Engineering & Design @ 20% of c			43056
e Supervision & Administration @ 6% of c			12917
f. overhead @ 5.6% of c			12,056
First Cost Total (features 1, 2 & 3) c+d+e+f			283,300

Annual Costs	COST
• Annual Cost on First Cost Items ($i = 7\frac{1}{8}\%$, $n = 50$ yr, CRF = 0.07361)	\$20,850
• Average Annual Maintenance Costs 5% of first cost of groin plus fees (1.51)	3,550
• Annual Cost of Beach Nourishment feature 4 ④ Minimum Federal Participation 2123 yd³/yr @ \$10/yd³	21,230
Total Annual Cost of Mitigation Alternative I	\$45,630

BENEFITS

1. UNDER ALTERNATIVE I, A 20-FOOT WIDE BEACH IS PLACED ALONG THE CURRENTLY ERODING SHORE AND A NOURISHMENT PROGRAM IS UNDERTAKEN THAT REDUCES THE EROSION RATE FROM 1.4 FEET/YEAR TO 1.0 FEET/YEAR (SEE PAGE E-20). THE NET RESULT IS THAT THE LIFE OF THIS RESTORED BEACH IS 20 YEARS. DURING THE FIRST 20 YEARS, THEREFORE, THE RESIDENTIAL LAND AND PROPERTY WILL NOT BE ERODED YIELDING AN ANNUAL SAVINGS OF \$7700 (FOR

VERMILION HARBOR, OHIO SECTION 111 STUDY

BENEFITS CONTINUED:

STRUCTURES) AND $9428 (FOR LAND). BECAUSE ONLY 29% IS ATTRIBUTABLE TO THE FEDERAL NAVIGATION STRUCTURES, THE ANNUAL SAVINGS FOR THESE ITEMS DURING THE FIRST 20 YEARS OF THE PROJECT WOULD BE $4967. DURING THE LAST 30 YEARS OF THE PROJECT, THE NOURISHMENT PROGRAM WOULD DECREASE THE AVERAGE EROSION RATE FROM THE PRESENT AGGRAVATED RATE (= 1.4 FEET/YEAR) TO THE "NATURAL" EROSION RATE (= 1.0 FEET/YR.). THIS BENEFIT CAN BE EXPRESSED AS 29% OF THE EXISTING RATE WHICH, AGAIN, WOULD EQUAL $4967.

THUS, THE AVERAGE ANNUAL BENEFIT FOR PROTECTION OF RESIDENTIAL LAND AND PROPERTY IS $<u>4967</u>.

2. THE RECREATIONAL BENEFITS THAT ACCRUE FROM IMPLEMENTATION OF ALTERNATIVE I ARE DOCUMENTED IN APPENDIX F (TABLE F-8).

AVERAGE ANNUAL RECREATIONAL BENEFIT = $29814

<u>TOTAL BENEFITS FOR ALTERNATIVE I = $34781</u>

<u>BENEFIT/COST RATIO = $34781/$45,630 = 0.76</u>

Benefits Continued:

20 ft wide beach restoration 360 feet in length is
$20(360) = 7200\ ft^2$
The value of this recreational benefit using the figures from Table 4, Section 5.2 is $\frac{\$2200}{3000\ ft^2} = .733\ \$/ft^2$

or $7200(.733) = \$5278$ /yr.
Since this beach is protected, this benefit should last for the 50 yr life ∴ annual average benefit = \$5278 /yr

(3) In the Sherod Park area ordinarily there would be a bluff / recreational loss of \$1383/yr per table 4 if no mitigation measures were undertaken. Under Alternative I, however, a 20 ft wide beach is placed along this shoreline and a nourishment program is undertaken which reduces the erosion rate from 1.4 ft/yr to 1.0 ft/yr (see page E-20). The net result is that the 20 ft beach restoration will last 20 yrs before the waves wash it away. During this first 20 years the bluff is protected and it will not erode. This equates to a benefit of $\frac{\$1383/yr \times 20\ yr}{50\ yr} = \$553$ yr average annual benefit
Also, during the last 30 yrs of project life, the erosion rate is reduced by 0.4 ft/yr as opposed to 1.4 ft/yr or by a factor of 0.286 - this can also be declared as a benefit $\frac{(.286)(1383)(30)}{(50)} = \$237$ /yr

total annual average benefit is \$790 /yr.

(4) The 20 ft wide beach at Sherod Park, as shown above, will last only 20 yrs at the reduced erosion rate of 1.0 ft/yr. Over this 20 yr period a recreational benefit can be derived similar to #2 above. Assuming an average 10 ft wide beach over the 20 yrs, the total area is 10 × 1400 or 14000 $ft^2 \times .733\ \$/ft^2 = \$10,262$ /yr
$\frac{10262 \times 20}{50} = \$4105$ annual average benefit

(5) Using similar reasoning to that of #3 above, other portions of the bluff will not erode for the first 20 yrs while a protective beach fronts them, but thereafter, will erode at a reduced rate. Using the average annual loss of residential land plus residential structures from table 4 now as a benefit the annual average benefit is
$\frac{(9428+9200)20}{50} + \frac{(9428+9200)(.286)(30)}{50} = \$10,648$ /yr

→ Total Benefits = \$20865 annually

→ Benefit/Cost Ratio = $20865/35800 = 0.583$

Vermilion Harbor, Ohio Section 111 Study

Evaluation of Mitigation Alternatives

Alternative II Beach Nourishment - Optimum Plan

If Alternative I is changed slightly to include local participation in the beach nourishment program the annual costs will increase but the benefits should increase much more.

major features of this alternative are:

① construction of a new groin fronting the Marine Museum at the location and orientation shown on figure -2;
② beach restoration east of this groin in areas which have eroded due to the navigation structures;
③ shoreline restoration from the groin west to Coen Road which is the assumed western limit of influence of the navigation works; and
④ a nourishment program which will deposit, on an annual basis, an amount of beach material equivalent to the annual amount of erosion attributable to the Federal Navigation Works over and above the natural erosion quantity which would occur had the navigation structures not been built.
⑤ an additional amount of nourishment financed by local interests which will replace, on an annual basis, the amount of material eroded by natural forces at the pre-navigation structures rate

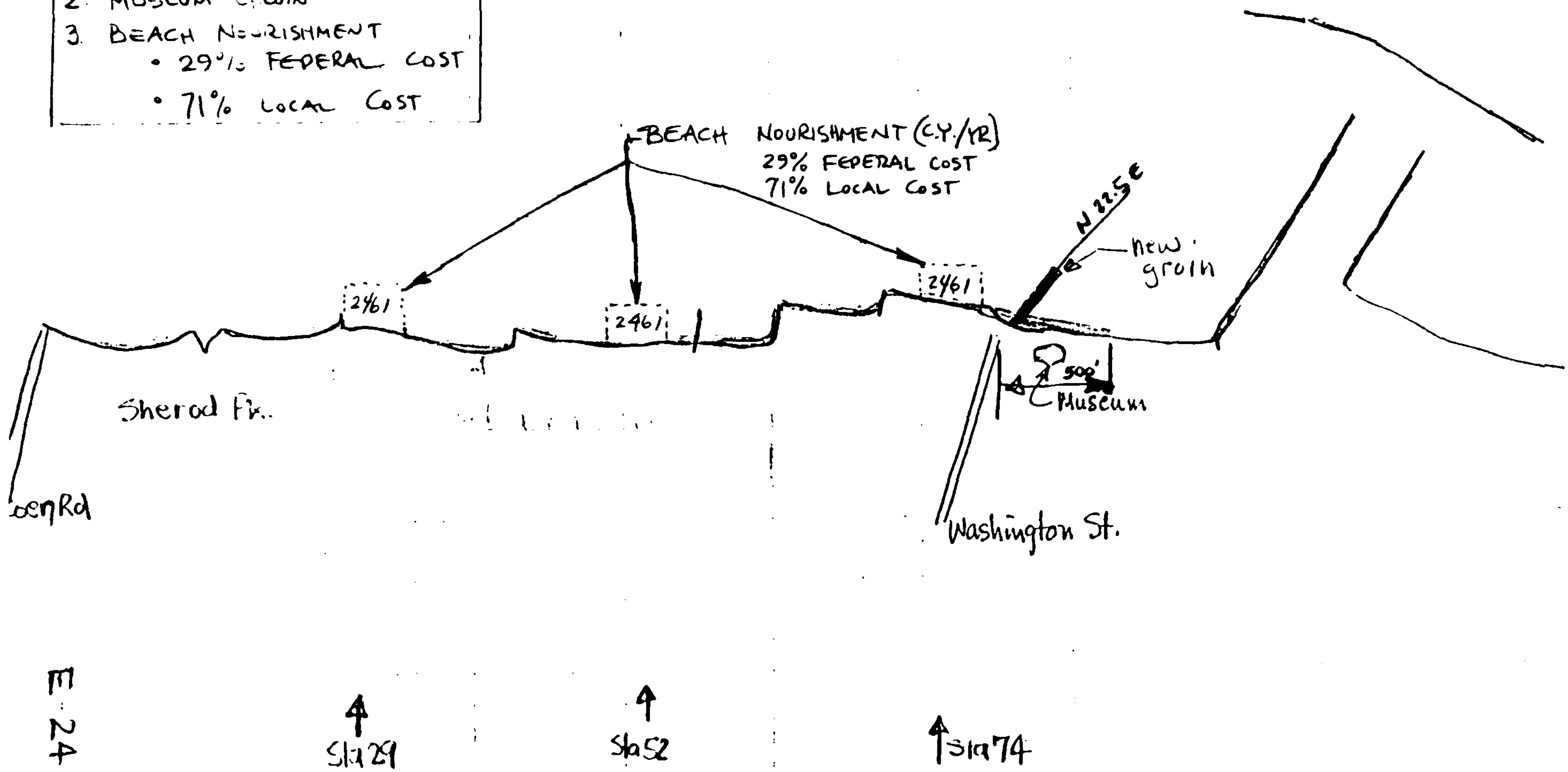
see figure E-9 for Alternative II physical features

The quantities and costs for the first four items are the same as presented in alternative I
Feature 5 requires an additional amount of beach nourishment needed to provide shore stability
ie, amout of beach material eroding equals amount made up in the nourishment program.
From page E-20
The total quantity needed for stability = 7384 yd^3/yr
The minimum federal share = 2123 yd^3/yr
The required local participation = 5261 yd^3/yr

In this alternative the 7384 yd^3/yr nourishment is placed in three equal parcels of 2461 yd^3/yr each at approximately ~~stations~~ stations 29, 52 and 74 depending upon access considerations

MAJOR FEATURES:

1. 20-FOOT WIDE BEACH RESTORATION (EXCEPT 500 FT ADJACENT TO WEST PIER).
2. MUSEUM GROIN
3. BEACH NOURISHMENT
   - 29% FEDERAL COST
   - 71% LOCAL COST



Beach Nourishment - Optimum Plan
Figure E-9 Mitigation Alternative II

Vermilion Harbor, Ohio Section 111 Study

Alternative II Cost/Benefit Analysis

COSTS

First Costs - features 1,2 & 3	Quantity	Unit Price	Cost
① Marine Museum Groin Construction			
Blanket Mtl 0.25 to 16 lbs	500 yd³	$27/yd³	13500
Head Armor 1450 to 3200 lbs	53 tons	$33/ton	1750
Trunk Armor 1050 to 2300 lbs	960 tons	$33/ton	31680
② Museum/City Beach Restoration	1087 yd³	$10/yd³	10870
③ Shoreline Restoration	12,940 yd³	$10/yd³	129400
a Subtotal			187200
b Contingency @ 15% of a			28080
c Subtotal a+b			215,280
d Engineering & Design @ 20% of c			43056
e Supervision & Administration @ 6% of c			12917
f. Overhead at 5.6% of c			12056
First Cost Total (features 1,2 & 3) c+d+e			$283,300

Annual Costs	COST
• Annual Cost on First Cost Items (i=7 1/8 %, n=50 yr, CRF= 0.07361)	20850
• Average Annual Maintenance Costs 5% of first cost of groin plus fees (1.51)	3550
• Annual Cost of Beach Nourishment features 4 & 5	
④ Minimum Federal Participation 2123 yd³/yr @ $10/yd³	21230
⑤ Local Participation 5261 yd³/yr @ $10/yd³	52,610
Total Annual Cost of Mitigation Alternative II	$98,200

BENEFITS

1. THE ACTIONS TAKEN IN ALTERNATIVE II WILL CAUSE THE EXISTING EROSION TO CEASE, YIELDING AN ANNUAL SAVINGS FOR RESIDENTIAL LAND OF $9428 AND FOR RESIDENTIAL PROPERTY OF $7700. THIS TOTAL SAVINGS OF $17,128 MUST BE REDUCED TO 29% OF THE

BENEFITS CONTINUED:

TOTAL FOR THIS ANALYSIS, OR $4967, BECAUSE ONLY 29% OF THE TOTAL EROSION IS ATTRIBUTABLE TO THE FEDERAL NAVIGATION STRUCTURES.

AVERAGE ANNUAL BENEFIT = $4967

2. RECREATIONAL BENEFITS DUE TO PRESERVATION OF EXISTING LANDS AND CREATION OF PUBLIC RECREATIONAL BEACHES HAVE BEEN COMPUTED IN APPENDIX F (TABLE F-8).

AVERAGE ANNUAL RECREATIONAL BENEFIT = $35,458

TOTAL AVERAGE ANNUAL BENEFITS = $40,425

BENEFIT/COST RATIO = $40,425 / $98200 = 0.41

Vermilion Harbor, Ohio Section 111 Study

Evaluation of Mitigation Alternatives

Alternative III Beach Nourishment and Short Groin Construction

major features of this alternative are:

① construction of a new groin fronting the Marine Museum at the location and orientation shown on figure -2;
② beach restoration east of this groin in areas which have eroded due to the navigation structures;
③ shoreline restoration from the groin west to Coen Road which is the assumed western limit of influence of the navigation works; and
④ a nourishment program which will deposit on an annual basis, an amount of beach material equivalent to the annual amount of erosion attributable to the Federal Navigation Works over and above the natural erosion quantity which would occur had the navigation structures not been built.
⑤ an additional amount of nourishment, financed by local interests, which will replace, on an annual basis, the amount of material eroded by natural forces at the pre-navigation structures rate
⑥ construction of a series of short groins along the shoreline between Washington St. and Coen Rd. which will serve to contain the restored and renourished shoreline

See figure E-10 for Alternative III physical features

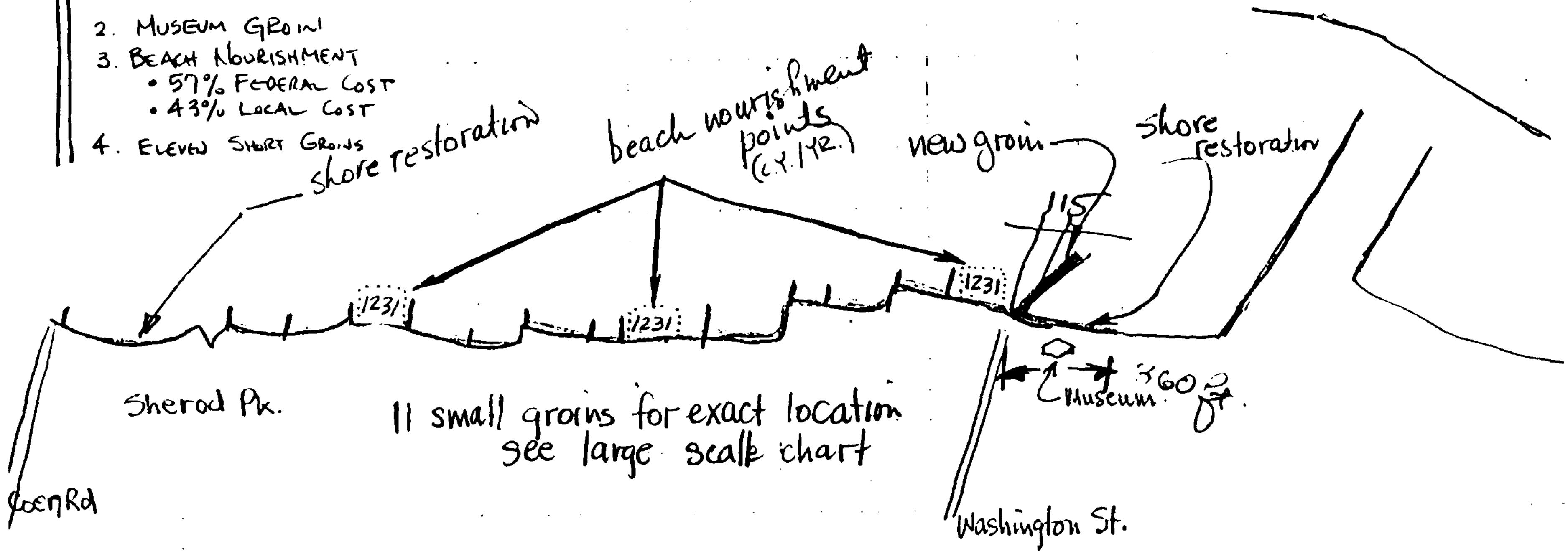
Features 1,2,3 and 4 are exactly the same as developed in Alternative I; therefore these quantities and costs will not be redeveloped.

Feature ⑤. The amount of local participation in a nourishment program depends upon the quantity of material which must be added to the federal share to attain shoreline stability. This of course depends upon the amount of material which the groin field will trap and maintain on the beach

From calculations for Alternative I pg E-20 the quantity of material needed along the 7100 feet of shoreline in the study area to attain shoreline stability is approximately 7384 yd^3/yr

MAJOR FEATURES:

1. BEACH RESTORATION
2. MUSEUM GROIN
3. BEACH NOURISHMENT
   - 57% FEDERAL COST
   - 43% LOCAL COST
4. ELEVEN SHORT GROINS



BEACH NOURISHMENT + GROIN CONSTRUCTION

Figure E-10 Mitigation Alternative III

Alternative III feature (5) continued

Assuming the newly constructed short groins are 50 % effective in maintaining a 20 ft increase in the shoreline over the life of the structures, then only 50 % of the shoreline material needed for stability has to be made up by beach nourishment.

$7384 (.50) = 3692$ yd³/yr

Of this 3692 yd³; 2123 yd³/yr will be financed by federal funds (amount attributable to navigation works)

Therefore 3692 − 2123 = 1569 yd³/yr must be financed by local funds

The total quantity of 3692 yd³/yr will be placed in 3 equal parcels of approximately 1231 yd³/yr each at stations 29, 52 and 74 depending upon access considerations.

Feature (6) Short Groin Construction

Extent of groin field: from new Marine Museum groin west to Coen Road

Spacing: by examining the chart of this stretch of shoreline, spacing was determined by usefullness of existing structures and the fit of new groins into a comprehensive plan to compartmentalize the shoreline with the minimum structural modifications (see figure E-10 for selected locations).

Orientation: use orientation normal to existing shoreline as the shortest groin to serve trapping function

Construction: for the purpose of this preliminary design rubble mound construction will be used due to the availability of this material. Final designs however, should consider timber, steel, or concrete sheet pile groins also.

Length & Size: will be determined by detailed beach profiles in final design. For these purposes only the assumed average profile can be used lacking better information.

As in the case of the Marine Museum Groin:
design lake level is 574.1 IGLD (+5.5) for storms
design wave period is T = 8.0 sec.

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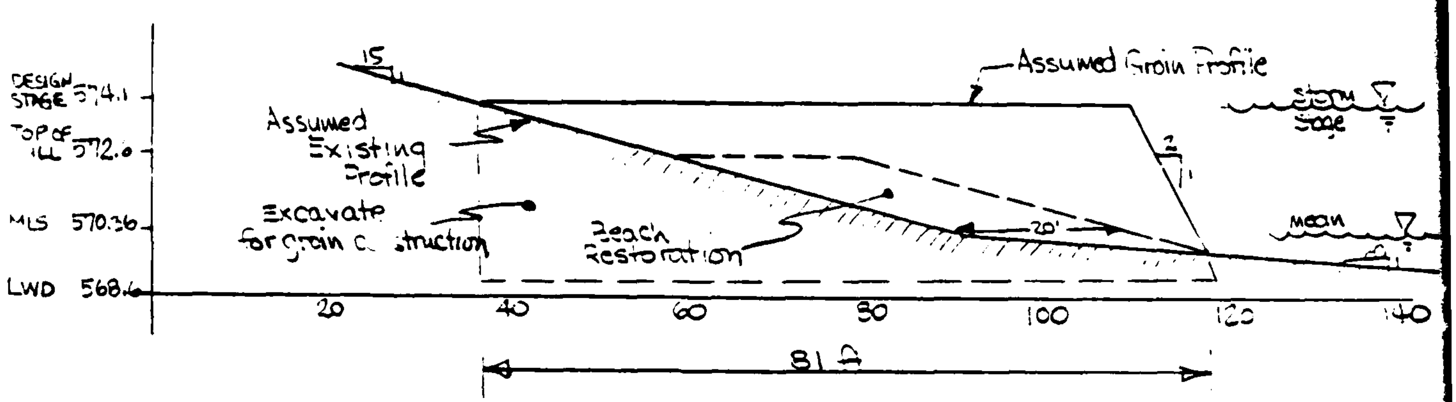
Feature 6 continued:



The figure above sets the elevation and length of an average groin at 574.1 IGLD and 81 feet respectively.
These groins need not be one foot higher than the fill they are designed to contain. In this case the groin crest is 1.5 feet above the fill elevation

Using breaking wave conditions to govern design

ds = depth of water at toe during storms = 4.2 feet
T = period of design wave = 8 sec
m = nearshore slope = 1:60 = 0.01667

$\frac{ds}{gT^2} = \frac{4.2}{32.2(8)^2} = 0.0020$ from figure 7-4 pg 7-9 of SPM

$Hb/ds = 0.95$ $\underline{Hb = .95(4.2) = 4.0 \text{ ft}}$

Note: Examination of the design wave was also performed utilizing guidance from a draft CERC report "Estimating Nearshore Conditions For Irregular Waves" by Seelig and Ahrens. The results of this analysis indicate a design wave height of 3.4 ft by irregular wave theory.
For the purposes of this design the slightly conservative monochromatic design wave height will be used since the difference in the design waves is negligible.

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Feature 6 continued

Assuming a rubble mound groin with side slopes of 1:2
Weight of armor units

$$W = \frac{w_r H^3}{K_D (S_r - 1)^3 \cot\theta}$$

$w_r = 160 \text{ lb/ft}^3$ $w_w = 62.4$
$H = 4.0$ $\cot\theta = 2.0$
$S_r = 2.56$ $K_D = 2.5$ (assume all head units)
for rough angular quarrystone in 2 layers

$$W = \frac{160\,(4)^3}{2.5\,(2.56-1)^3\, 2} = 540 \text{ lbs}$$

Size variation allowed 0.9W to 2.0W or Armor Stone <u>490 to 1080 lbs</u>

First Underlayer (if any) size: varies 0.06W to 0.2W or <u>32 to 108 lbs</u>

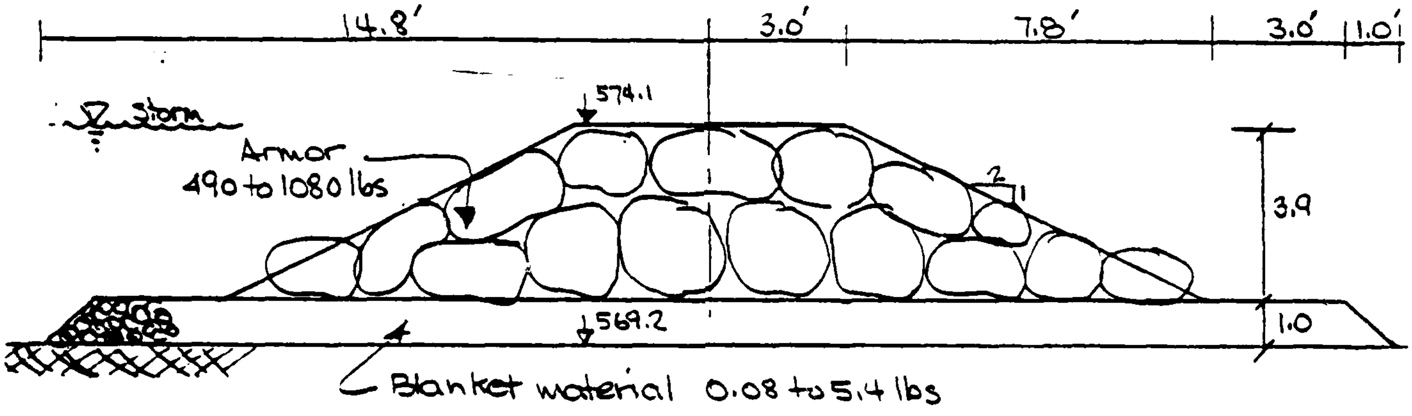
Bedding layer (blanket) size: varies 0.00015 to 0.01W or <u>0.08 to 5.4 lbs</u>

Thickness of Armor layer: $r = n k_\Delta \left(\frac{W}{W_r}\right)^{1/3} = 2\,(1.15)\left(\frac{785}{160}\right)^{1/3}$ <u>$r = 3.9$ ft</u>

Crest width: $B = n k_\Delta \left(\frac{W}{W_r}\right)^{1/3} = 3\,(1.15)\left(\frac{785}{160}\right)^{1/3} = 5.9$ <u>say B = 6.0 ft</u>

Crest Elevation: 574.1 IGLD

Allowing for a 1 foot blanket layer and a 3.9 ft thick Armor layer (no first underlayer) the cross section of the groin will be as shown below



Feature 6 continued:

New ~~total~~ length of groin including bedding layer is 83 ft

To accomodate the full cross section of the groin for a significant portion of its length it is necessary to excavate the beach for groin construction

Excavation Quantities

from break in slope to toe — length = 28 ft depth = $\frac{1.3+0.7}{2}$ = 1.0 ft
width = 14.8 x 2 = 29.6 ft
Volume = 829 ft^3

from landward end to break in slope — length = 55 ft depth = $\frac{4.9+1.3}{2}$ = 3.1 ft
width = 29.6 ft
Volume = 5047 ft^3

Total volume 5875 ft^3 = 217 yd^3

Approximately 50 yd^3 of this must be replaced to fill out the beach to its original profile around the groin

Excavation ~~totals~~ for 11 Groins

Total Volume excavated	217 x 11 = 2387	say	2400 yd^3
volume replaced	50 x 11 = 550		550 yd^3
volume available for beach restoration feature 3			1850 yd^3

Beach Restoration Volume of 12940 yd^3
is reduced by 1350 yds^3 from excavation
and by say 50 x 11 = 550 yd^3 for width of 11 groins which don't have to be restored
12940 − (1850 + 550) = 10540 yd^3 = new beach restoration volume

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Feature 6 continued:

Groin quantity take offs

Blanket layer at roundhead

average radius $(3+7.8+3+\frac{1.0}{2} = 14.3\ ft)$

area $= \frac{1}{2}\pi R^2 = \frac{1}{2}\pi(14.3)^2 = 321\ ft^2$

volume $= 1.0 ft (321) = 321\ ft^3$

Blanket layer for trunk

average width is $2(14.3) = 28.6 ft$

length is $83' - 14.3' = 68.7 ft$

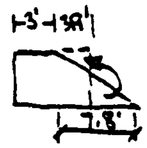
thickness is 1.0 ft

volume $= 28.6(68.7)(1.0) = 1965\ ft^3$

Total blanket volume per groin is $2286\ ft^3 = 85\ yd^3$

for 11 groins blanket volume = $935\ yd^3$
of 0.08 to 5.4 lbs stone

Armor layer at roundhead



surface area of a 2 stone thick (3.9') volume

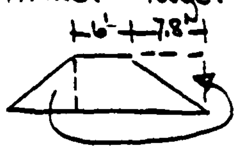
$A = \frac{1}{2}\pi R^2 = \frac{1}{2}\pi(3+3.9)^2 = 74.8\ ft^2$

number of armor units needed $N_r = 74.8(2)(1.15)(.63)\left(\frac{160}{785}\right)^{2/3}$

$\frac{490+1080}{2} = 785 =$ average unit weight

$N_r = 38$ units

Armor layer for trunk



surface area of trunk is 68.7 ft long × 13.8 ft wid or $948\ ft^2$ for a 2 stone thick layer

$N_r = 482$ units

Total Armor per groin 520 units @ 785 lbs = 408,200 lbs = 204 tons

for 11 groins armor needed = 2245 tons
of 490 to 1080 lb units

Vermilion Harbor, Ohio Section 111 Study

Alterrative III Cost/Benefit Analysis

Costs

First Costs Features 1,2,3 and 6	Quantity	Unit Price	Cost
① Marine Museum Groin Construction	see Alt #I		46930
② Museum/City Beach Restoration	$1087 yd^3$	\$10/yd^3	10870
③ Shoreline Restoration	$10540 yd^3$	\$10/yd^3	105400
⑥ 11 Short Groins			
Excavation and Rehandling	$2400 yd^3$	\$7.50/yd^3	18000
Blanket Material (0.08 to 5.4 lbs)	$935 yd^3$	\$27/yd^3	25250
Armor Units (490 to 1080 lbs)	2245 tons	\$44/ton	98780
a Subtotal			305230
b Contingency @ 15% of a			45785
c Subtotal			351,015
d Engineering & Design @ 20% of c			70,203
e Supervision & Administration @ 6% of c			21,060
f overhead @ 5.6% of c.			19657
First Cost Total (features 1,2,3 & 6) c+d+e			\$461,930

Annual Costs	Cost
• Annual Cost on First Cost Items (i=7 1/8 %, n=50yr, CRF=.0732)	34,000
• Average Annual Maintenance Costs 5% of first cost of groins plus fees (1.51)	14,300
• Annual Cost of Beach Nourishment features 4 & 5	
④ Minimum Federal Participation - 2123 yd^3/yr @ \$10/yd^3	21230
⑤ Local Participation - 1569 yd^3/yr @ \$10/yd^3	15690
Total Annual Cost of Mitigation Alternative III	\$85,220

Benefits

Since in this alternative the shoreline is restored and stabilized by groins and annual nourishment, the benefits on an annual basis are the same as for alternative II

Average Annual Benefit = \$40,425/yr.

Benefit/Cost Ratio for Alternative III = $\frac{\$40,425}{\$85,220} = 0.47$

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Evaluation of Mitigation Alternatives

Alternative IV: Bluff Revetment

major features of this alternative are:

1. construction of a new groin fronting the Marine Museum
2. beach restoration east of this groin in the Museum/City Beach area
3. Construction of a revetment from the Museum groin west to Coen Rd for the purpose of bluff protection.

See figure E-11 for Alternative IV physical features

Features 1 and 2 are the same as those developed in Alternative I for costs and quantities.

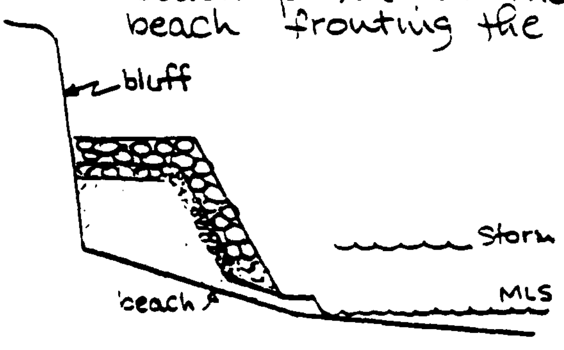
Since a total revetment of the remaining 7100 feet of shoreline totally protects the bluff from erosion and recession, no annual nourishment is needed to stabilize the bluffline.

Revetment Preliminary Design and Quantities

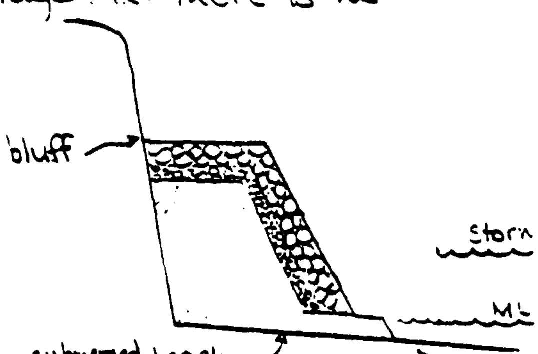
In order to size out the revetment, it is necessary to know where on the profile of the beach does the bluff toe intersect. In studying aerial photographs, it is obvious that the beach length in front of the bluff varies along the 7100 feet of shore in question.

To provide adequate bluff protection with minimum revetment quantities, the revetment would be constructed backed up to the bluff. Where seawalls or other existing structural elements exist, the revetment would back up to these or incorporate them in the revetment cross section.

The worst case for design, from the stand point of size of armor units and quantity of core material needed, would occur when the toe of bluff intersects the beach profile at the mean lake stage ie. there is no beach fronting the bluff.



most probable condition



assumed condition

MAJOR FEATURES:

1. BEACH RESTORATION (360' OF VERMILION CITY BEACH)
2. MUSEUM GROIN
3. REVETMENT ENTIRE SHORELINE (MUSEUM GROIN TO COEN ROAD)

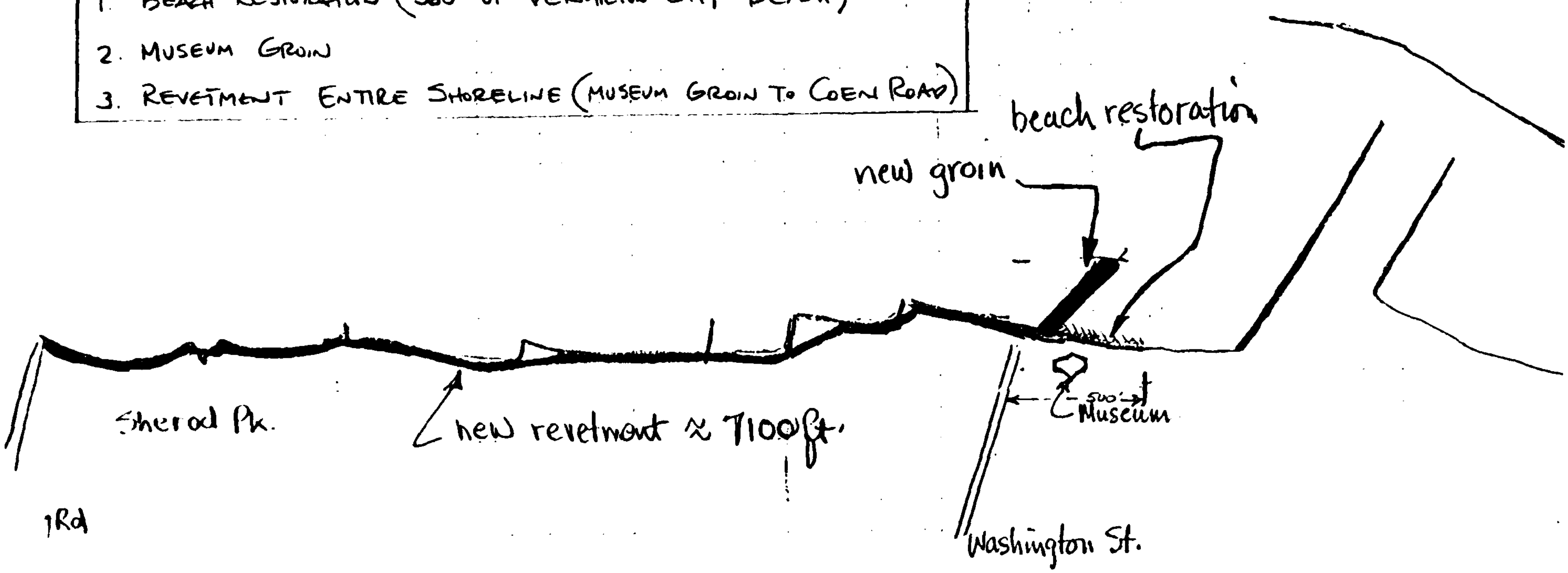


Figure E-11 Mitigation Alternative IV

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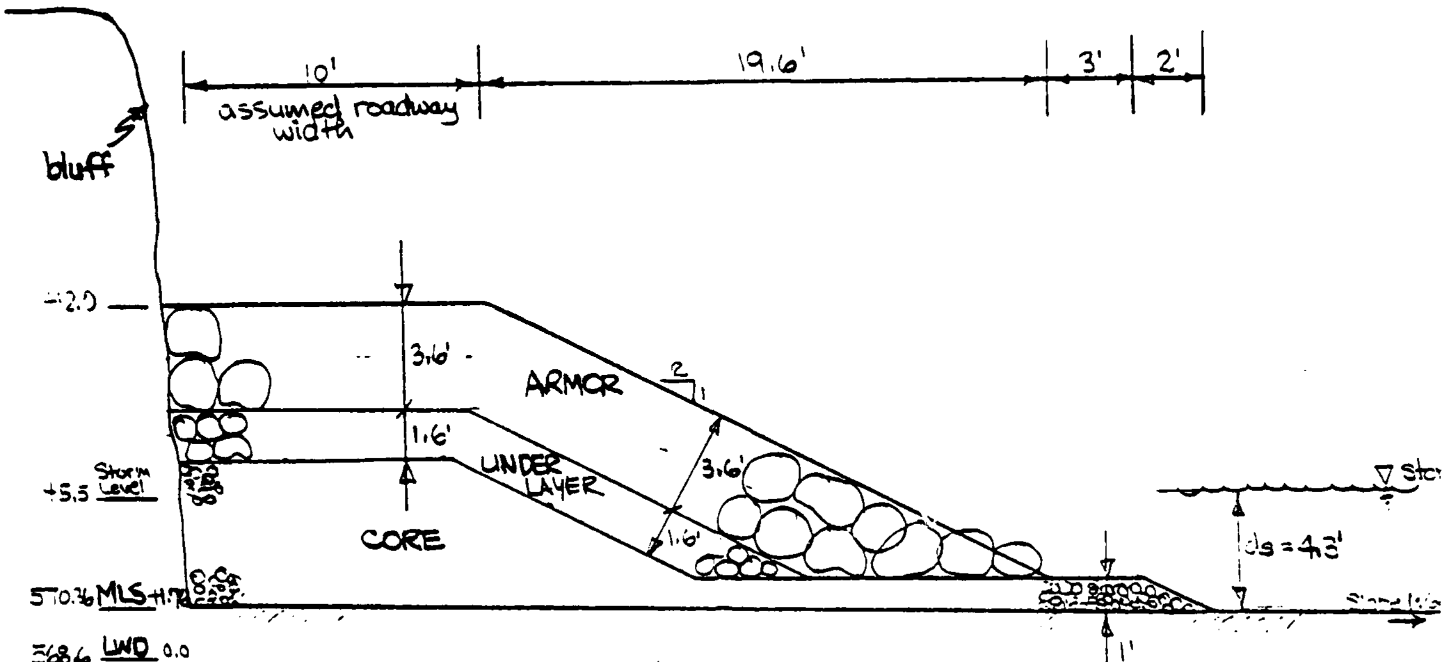
Alternative IV - Revetment Preliminary Design



$y = -\frac{x}{2} + 12 + \frac{10+3}{2} = y = -\frac{x}{60} + 1.76 \Rightarrow x = 34.6 \quad y = +1.18$

$5.5 - 1.18 = 4.3'$ $34.6 - [10+3+2] = 19.6$

from above sketch $d_s = 4.3'$ depth of water at toe

slope fronting structure $1:60 = m$

period of incoming storm waves $T = 8$ sec.

$d_s/gT^2 = 0.0021$ from figure 7-4 pg 7-9 of SPM $H_b/d_s = 0.95$

$m = 0.0167$. $H_b = .95\,(4.3) = 4.1$ ft

Note: this wave height is conservative compared to that determined using irregular wave theory.

use figure 7-5 to find deepwater wave height H_o' associated with H_b

$\frac{H_b}{gT^2} = 0.002$ $m = 0.0167$ $\frac{H_b}{H_o'} = 1.5$ $H_o' = 2.74$ ft

$\frac{H_o'}{gT^2} = 0.0013$ rubble slope 1 on 2 from figure 7-20 SPM $\frac{R}{H_o'} = 1.1$

this is highest R/H_o' ratio for any period — with $H_o' = 2.74$ ft

$\therefore$ $R = 1.1\,(2.74) = 3.01$ ft = vertical height of runup.

minimum vertical height of structure is $+5.5 + 3.01 = +8.51$ ft (LWD)

the +12.0 elevation of revetment assumed is more than adequate

RG.

Vermilion Harbor, Ohio Section 111 Study

Revetment Design Parameters

Section as shown is OK for wave runup and overtopping

- Design of armor layer: using rough angular quarrystone units

$$W = \frac{w_r H^3}{K_D (S_r - 1)^3 \cot\theta}$$

$w_r = 160\ lb/ft^3$ $\quad \cot\theta = 2$
$H = 4.1\ ft$ $\quad n = 2$
$S_r = 2.56$ $\quad K_D = 3.5$

$W = 415\ lbs$ size variation allowed $.9W$ to $2.0W$ → $\underline{375\ lbs + 830\ lbs}$ armor

- Minimum Crest Width: $B = n k_\Delta \left(\frac{W}{w_r}\right)^{1/3}$ $\quad n = 3 \quad k_\Delta = 1.15$
$W = \frac{375 + 830}{2} = 602.5$

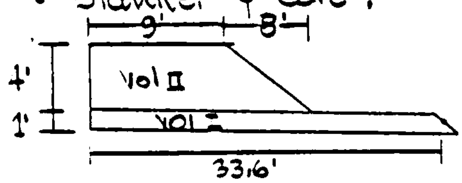
$B = 5.4\ ft$

Since $B = 5.4\ ft < 10\ ft$ assumed roadway width 10 ft is OK

- Thickness of Armor: $r = n k_\Delta \left(\frac{W}{w_r}\right)^{1/3}$ $\quad n = 2 \quad r = 3.6\ ft$
- Size of underlayer: variation allowed $0.06W$ to $0.2W$
$\underline{\text{underlayer } 25\ lbs \text{ to } 83\ lbs}$
thickness $r = 2(1.15)\left(\frac{54}{160}\right)^{1/3} = 1.6\ ft$
- Size of blanket and core: variation allowed $0.00015W$ to $0.01W$
$\underline{\text{blanket } 0.06\ lbs \text{ to } 4.15\ lbs}$

Revetment Quantity Take Offs

- Blanket & Core:



per foot of revetment
Vol I $= 33.6 \times 1 \times 1 = 33.6$
Vol II $= 1 \times [4 \times 9 + \frac{1}{2} \times 8] = 52.0$ $\quad \} = 85.6\ ft^3/ft$

Volume of blanket $= 3.17\ yd^3/ft$
$\underline{\text{for } 7100\ ft \quad \text{blanket volume} = 22510\ yd^3}$

- underlayer: find the surface area for a 2 stone thick layer from cross section midlength $L = 20.3'$ $W = 1.0'$ $A = 20.3\ ft^2$
$N_r = 20.3\,(2)(1.15)(.63)\left(\frac{160}{54}\right)^{2/3} = 60.68$ units/ft @ average 54 lbs
$\underline{\text{for } 7100\ ft \quad \text{underlayer} = {}^{\sim}11{,}632 \text{ tons}}$
- armor layer: find the surface area for a 2 stone thick layer from cross section midlength $L = 27.3'$ $W = 1.0'$ $A = 27.3\ ft^2$
$N_r = 27.3\,(2)(1.15)(.63)\left(\frac{160}{602.5}\right)^{2/3} = 16.34$ units/ft @ average 602.5 lbs
$\underline{\text{for } 7100\ ft \quad \text{armor} = 34{,}949 \text{ tons}}$

Vermilion Harbor, Ohio Section 111 Study

Alternative IV Cost / Benefit Analysis

Costs

First Costs - features 1,2,3	Quantity	Unit Price	COST
① Marine Museum Groin Construction	see Alt #I		46930
② Museum / City Beach Restoration	1087 yd³	$10/yd³	10870
③ Bluff Revetment			
Blanket Material (0.06 to 4.15 lb)	22510 yd³	$27/yd³	607770
Underlayer Stone (25 to 83 lbs)	11632 tons	$40/ton	465280
Armor Stone (375 to 830 lbs)	34949 tons	$44/ton	1537760
a Subtotal			2668610
b Contingency @ 15% of a			400 290
c Subtotal a+b			3,068,900
d Engineering & Design @ 20% of c			613,800
e Supervision & Administration @ 6% of c			184,100
f. Overhead @ 5.6% of c.			171,850
FIRST COST TOTAL (all features) c+d+e			$4,038,700

Annual Costs	COST
• Annual Cost on First Cost Items (i = 7 1/8%, n = 50 yrs, CRF 0.07361)	297,300
• Average Annual Maintenance Costs 5% of first costs of groin ① plus revetment ③ plus fees 0.05 [2668610 - 10870] (1.)	200,700
Total Annual Cost of Mitigation Alternative IV	$498,000

BENEFITS

1. SINCE THE ENTIRE SHORELINE FROM THE MUSEUM GROIN TO COEN ROAD IS REVETTED AND, THEREFORE, STABLE, BENEFIT #1 FROM ALTERNATIVE II IS APPLICABLE FOR THIS ALTERNATIVE ALSO.

AVERAGE ANNUAL BENEFIT FOR SAVINGS OF RESIDENTIAL LAND AND PROPERTY = $4967

2. THE RECREATIONAL BENEFITS FOR ALTERNATIVE IV HAVE BEEN COMPUTED IN APPENDIX F (TABLE F-8).

ANNUAL AVERAGE RECREATIONAL BENEFIT = $10,984

BENEFITS CONTINUED:

TOTAL AVERAGE ANNUAL BENEFITS = $15,951

$$\text{BENEFIT/COST RATIO FOR ALTERNATIVE } \underline{\text{IV}} = \frac{\$15951}{\$498{,}000} = 0.032$$

APPENDIX F

LOSSES TO RECREATIONAL USAGE

The extent of recreational damages caused by the Federal harbor structures at Vermilion must be determined to find the benefits attributable to any proposed mitigation measure. The methodology used in this regard is to find the expected annual loss of beach or parkland due to ongoing erosion processes and to assign to that area, a value that quantifies the lost recreational usage. In this way, annual recreational benefits of the erosion mitigation measures can be determined.

The two public recreation lands that exist within the study reach are Vermilion City Beach and Sherod Park. Annual attendance figures are not available for these two parks, thus necessitating a series of subjective judgments to determine the value of the future recreational losses. The choice of methods for determining recreational losses complies with those methods used in the syllabus to the Section 111 Study for the East Side of Vermilion Harbor (U.S. Army, Corps of Engineers, 1978).

While it has been determined that the City Beach will lose a small amount of beach area in the future, the beach fronting Sherod Park is expected to maintain a constant width as the bluff recedes. For this reason, Sherod Park will not sustain a future loss of recreational <u>beach</u> area. However, the park bluff will recede leading to a loss of park-related recreation area. For both City Park and Sherod Park, the increase or decrease in beach or park capacity was estimated based on 75 square feet of area per person. The 75 square feet per user at time of peak use is considered to be the minimum needed to obtain optimum benefit from both a beach visit, and for a visit to the bluff edge that is now currently experiencing erosion. Under peak conditions, a utilization rate of 30% of total capacity is assumed for both these recreation areas. This utilization figure was suggested by the City of Vermilion for City Beach (Stanley Consultants, 1978) and has been accepted by the Buffalo District. A value of utilization for Sherod Park is not available from the city due to the lack of attendance records. Therefore, it has been assumed that the currently

eroding bluff edge would experience an 80% utilization rate under maximum usage. This high value is due to the recreational popularity of the lakefront bluff and reflects a maximum utilization that exceeds the level for the other areas of Sherod Park where specific recreational activities (baseball, football, and other games) yield lower utilization figures. The "75 square foot per user" criteria was obtained from the Corps of Engineers document, "Digest of Water Resources Policies", EP 1165-2-1, 1975.

To relate the change in beach or park area to the annual recreational benefit, an estimate of the total annual number of "user visits" and the value of a "user visit" is required.

Weekend days and holidays are considered "peak days". The number of weekend days and holidays between Memorial Day weekend and Labor Day is 33. For computation purposes, it is assumed that 7 (22 percent) of these days are lost to bad weather, leaving 26 good weather "peak days". There are about 100 days in the summer season, and about 67 of these (100 days total -33 "peak days") are "nonpeak" days. Again, assuming that 22 percent of the "nonpeak" days per year have bad weather, only 52 days are considered "nonpeak" days. Thus, 26 "peak days" and 52 "nonpeak" days will be used for the benefit analysis. To promote conservatism, no utilization of the beach or park is considered during non-summer months.

Typically, an individual user does not spend the entire day at the beach or park, and is replaced by another user. Therefore, a turnover factor of 2.0 was used to represent attendance figures for "peak days". Also, a recreational facility normally is not utilized to full capacity on a given day. As stated previously, based on information provided by city officials it is estimated that there is an 80 percent utilization rate at Vermilion City Beach for "peak days".

Attendance figures for Sherod Park were not available, therefore, an 80 percent utilization "peak day" rate was assumed for this area also. Utilization at both City Beach and Sherod Park for "nonpeak days" was assumed to be one-third of the "peak day" attendance. Based on all these

factors, the estimated potential decrease in annual attendance due to shore erosion at City Beach and Sherod Park was computed as shown in Table F-1.

TABLE F-1: Present Annual Recreational User Loss

	Annual Area Loss (SF) (Appendix D)	Peak Day[A] Loss (Users)	Non-Peak[B] Day Loss (Users)	Total[C] Annual User Loss
Sherod Park	1,890	1,048	681	1,729
City Beach	60	33	22	55

A. Peak Day Loss = $\frac{\text{Area Loss (SF)}}{\text{75 SF/User}} \times 2 \frac{\text{Users}}{\text{Day}} \times 80\%$ Utilization $\times 26 \frac{\text{Peak Days}}{\text{Year}}$

B. Non-Peak Day Loss = $\frac{\text{Area Loss (SF)}}{\text{75 SF/User}} \times 2 \frac{\text{Users}}{\text{Day}} \times \frac{80\%}{3} \times 52 \frac{\text{Non-Peak Days}}{\text{Year}}$

C. This equates to 0.915 users/SF on an average annual basis.

Once the annual user loss is known, a value for each user visit must be estimated. This has been done using information contained in "Procedures for Evaluation of National Economic Development Benefits and Costs in Water Resources Planning", Water Resources Council, 1979. In this document, a point system was developed to evaluate the level of "value" of a recreation area. Table F-2, taken from the Water Resources Council document, shows the method by which Sherod Park and City Beach have been judged. For the basic criteria given, the two areas have been assigned "scores" as follows:

Guidelines for Assigning Points for General Recreation

Criteria	Judgment Factors				
a) Recreation Experience	Two general activities 3/	Several general activities	Several general activities; one high quality value activity 4/	Several general activities; more than one high quality high activity	Numerous high quality value activities; some general activities
Total Points: 30					
Point Value:	0–4	5–10	11–16	17–23	24–30
b) Availability of Opportunity 7/	Several within 1 hr. travel time; a few within 30 min. travel time	Several within 1 hr. travel time; none within 30 min. travel time	One or two within 1 hr. travel time; none within 45 min. travel time	None within 1 hr. travel time	None within 2 hr. travel time
Total Points: 18					
Point Value:	0–3	4–6	7–10	11–14	15–18
c) Carrying Capacity 1/	Minimum facility development for public health and safety	Basic facilities to conduct activity(ies)	Adequate facilities to conduct without deterioration of the resource or activity experience	Optimum facilities to conduct activity at site potential	Ultimate facilities to achieve intent of selected alternative
Total Points: 14					
Point Value:	0–2	3–5	6–8	9–11	12–14
d) Accessibility	Limited access by any means to site or within site	Fair access poor quality roads to site; limited access within site	Fair access, fair road to site; fair access, good roads within site	Good access, good roads to site; fair access, good roads within site	Good access, high standard road to site; good access within site
Total Points: 18					
Point Value:	0–3	4–6	7–10	11–14	15–18
e) Environmental Quality	Low esthetic factors 5/ exist that significantly lower quality 6/	Average esthetic quality; factors exist that lower quality to minor degree	Above average esthetic quality; any limiting factors can be reasonably rectified	High esthetic quality; no factors exist that lower quality	Outstanding esthetic quality; no factors exist that lower quality
Total Points: 20					
Point Value:	0–2	3–6	7–10	11–15	16–20

1/ Value should be adjusted for overuse.
2/ Value for water-oriented activities should be adjusted if significant seasonal water level changes occur.
3/ General activities include those that are common to the region and that are usually of normal quality. This includes picnicking, camping, hiking, riding, cycling, and fishing and hunting of normal quality.
4/ High quality value activities include those that are not common to the region and/or Nation and that are usually of high quality.
5/ Major esthetic qualities to be considered include geology and topography, water, and vegetation.
6/ Factors to be considered in lowering quality include air and water pollution, pests, poor climate, and unsightly adjacent areas.
7/ Likelihood of success at fishing and hunting.
8/ Intensity of use for activity.

TABLE F-2

VALUE OF RECREATION

CRITERIA	SHEROD PARK		CITY BEACH	
	Score	Justification	Score	Justification
1. Recreational Experience	8	Picnic, hiking, fishing, swimming	3	Swimming, picnic, sightseeing
2. Availability of Opportunity	5	Lakeview Park, Lorain None comparable in Vermilion	3	Small beaches are available elsewhere
3. Carrying Capacity	4	Basic facilities (parking, restrooms, baseball, etc.)	2	Limited facilities
4. Accessibility	9	Good road, close to town	11	Near downtown, easily accessible
5. Environmental Quality	8	Good quality, quiet, serene	6	In town, noise, traffic
Total:	34		25	

TABLE F-3: CONVERSION OF POINTS TO DOLLAR VALUES

	Points		
	20	30	40
General Recreation:	$1.44	$1.68	$1.93

25 Points = $1.50   34 Points = $1.75

Value of Visit: Sherod Park = $1.75
City Beach = $1.50

Based on these scores, Table F-3 is taken from the Water Resources Council report to convert the point score to a recreational dollar value for a "user visit". Using interpolation of these tabular values, the maximum value of a visit to Sherod Park is determined to be $1.75 and a visit to City Beach is judged to be worth $1.50.

Thus, the annual value of the loss of recreational land at City Beach and Sherod Park is as follows in Table F-4.

TABLE F-4: RECREATION LOSSES DUE TO EROSION

	Annual Area Loss (SF)	Annual User Loss	Value of User Visit	Total Loss
Sherod Park	1,890	1,729	$1.75	$3,026
City Beach	60	55	$1.50	$ 83
			Total Loss:	$3,109

The level of demand for recreational area in the vicinity of Vermilion has been studied in a recent document prepared by the State of Ohio.

The "Ohio Statewide Comprehensive Outdoor Recreation Plan" (1975) determined that the following recreational needs exist in the area containing Erie, Sandusky, Ottawo, Lucas, and Wood Counties:

	1975	1980	1990
Total Beach Area Required (SF)	753,000	889,000	1,151,000
Additional Beach Capacity Required (Spaces at 75 SF/space)	10,000	11,800	15,300

Based on these figures, the current demand for recreational areas near Vermilion that allow swimming is nearly 12,000 spaces. By immediately halting the ongoing erosion at Vermilion, the annual savings in terms of beach visits is 1,784 (1,729 at Sherod Park, 55 at City Beach). This represents 15% (= 1,784/11,800) of the present beach area needed to meet the existing demand.

The Section 111 study conducted to the east of Vermilion Harbor recommends erosion mitigation measures that will create additional beach space that is equal to 11% of the present demand. (U.S. Army, Corps of Engineers, 1978).

Based on these considerations, it is judged that if the ongoing erosion processes at these two recreation areas are halted, there exists a need for the recreational benefit provided by the preserved lands. It is further believed that, based on the documented demand for recreational beach space, the utilization figures used in the economic analysis of recreational benefits are valid.

To this point, we have attempted to justify the recreational need for the shore and bluff areas of both City Beach and Sherod Park. It appears as if the halting of the present shore and bluff recession will result in the preservation of needed and desired recreational lands.

As a means of halting the ongoing erosion processes, several of the erosion mitigation alternatives propose beach replenishment plans that will add an additional 20 feet to the existing beach width. This beach will serve as a buffer between the fragile bluff and the erosive force of the lake. In addition, this buffer beach will also hold value as a recreational resource. This resource can be included in the benefit computation with the understanding that in both alternatives II and III, the widened beach will be nourished annually to retain its width over the 50-year anticipated life of the mitigation plan. The benefit computation for the widened beach is complicated, however, when one realizes that initially, this beach construction will create recreational space that exceeds the existing demand. This complication is best illustrated in Table F-5.

It must, therefore, be understood that creation of added beach space, in excess of the presently eroding area, will increase the existing recreational beach space to a level that exceeds the current demand.

TABLE F-5

UTILIZATION COMPUTATION

MITIGATION ALTERNATIVE	BEACH CONSTRUCTION: City Beach	BEACH CONSTRUCTION: Sherod Park	BEACH REPLENISHMENT: City Beach	BEACH REPLENISHMENT: Sherod Park	AREA ADDED BEACH SPACE (SF)	AREA OF PROTECTED BEACH SPACE (SF)	ADDED ANNUAL BEACH CAPACITY (USERS)	CURRENT USER NEED	PRESENT MAX UTIL
I	Yes	Yes	No	No	20,200	1,950	20,157	11,800	59%
II	Yes	Yes	No	Yes	33,200	1,950	32,162	11,800	37%
III	Yes	Yes	No	Yes	33,200	1,950	32,162	11,800	37%
IV	Yes	No	No	No	7,200	1,950	8,372	11,800	71%

A. Sherod Park: 20'x1300' = 26000 SF
City Beach : 20'x 360' = 7200 SF

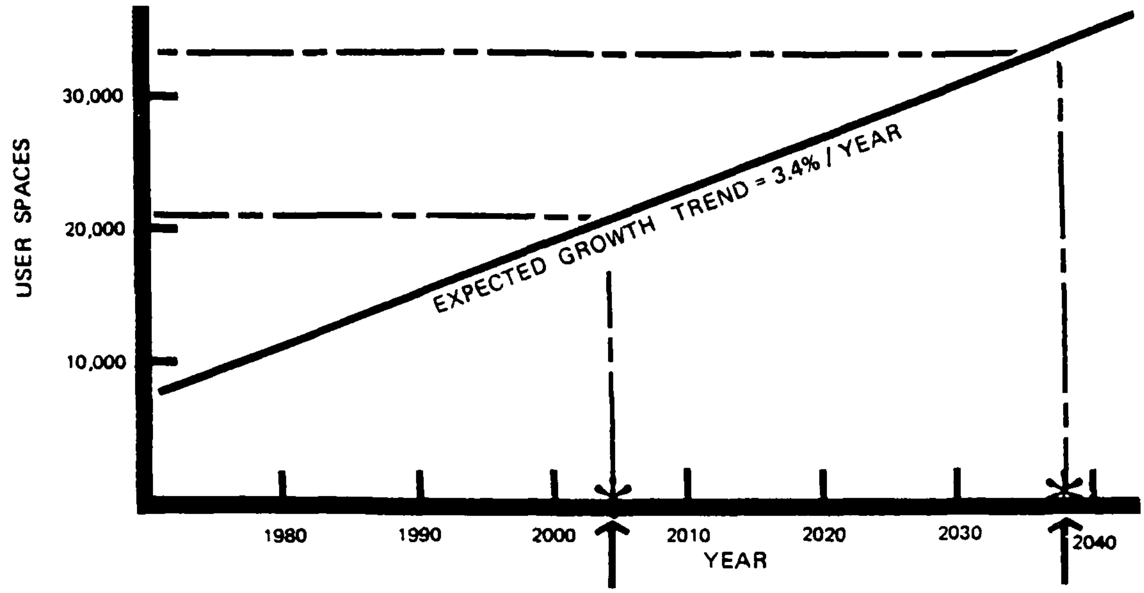
B. Area saved if erosion was halted and no buffer beach was constructed, from Appendix D, p. D-4.

C. This assumes 0.91 User/SF as shown in Table F-3 (i.e. 80% maximum utilization)

D. From "Ohio Statewide Comprehensive Outdoor Recreation Plan", 1975.

One can assume, however, that as time passes, population growth will create an ever increasing demand for recreation space. The following graph shows the future growth of recreational beach space demand and predicts the time at which each alternative mitigation plan achieves a maximum utilization level.

Thus, the beach space produced by the beach construction of the various erosion mitigation alternatives (with the exception of Alternative IV) currently significantly exceeds the present level of demand. The space provided in Alternative I will achieve maximum utilization in about 2009 A.D., Alternatives II and III in 2043 A.D., while Alternative IV was found to provide beach space that will immediately exhibit a maximum utilization level.



*: DATE OF 80% UTILIZATION

FIGURE F-1: EXPECTED RECREATIONAL DEMAND FOR FIVE COUNTY AREA NEAR VERMILION, OHIO

SOURCE: OHIO STATEWIDE OUTDOOR RECREATION PLAN, 1975

To determine an average value for maximum utilization over the future 50 year period, one might assume that the existing utilization will steadily climb to the 100% level and then remain at that level for the remaining life of the 50 year period. It is believed that this is unrealistic, however because the anticipated recreational needs used in this analysis (from "Ohio Statewide Comprehensive Outdoor Recreation Plan, 1975) are for a five county area that contains Vermilion. It is unreasonable to assume that by filling the expected need for the five county area at only one location, the needs for the entire area will be met. It seems that travel requirements would dictate that only through a wise distribution of recreational space throughout the total area would 100% utilization of recreation space be achieved. For this reason, it has been assumed that the present utilization levels will steadily climb to the 80% value and remain at that figure for the remaining life of the project. Thus, maximum recreational utilization levels of greater than 80% are not expected in the future at City Beach and Sherod Park. Based on this belief, the average maximum utilization factor can be computed for

the 50 year project life of each alternative, as shown in Table F-6.

TABLE F-6

AVERAGE UTILIZATION COMPUTATION

ALTERNATIVE	1 ADDED ANNUAL BEACH CAPACITY	2 1980 MAXIMUM UTILIZATION	3 YEAR 80% UTILIZATION ACHIEVED	4 AVERAGE MAXIMUM UTILIZATION 1980 - 2030*
I	20157	59%	2004 A.D.	75%
II	32162	37%	2038 A.D.	55%
III	32162	37%	2038 A.D.	55%
IV	8372	71%	1970 A.D.	80%

$$* \; 4 = \frac{\left[2 + \left(80\% - 2\right)\right]\left(3 - 1980\right) + 80\% \left(2030 - 3\right)}{50}$$

Thus, using average maximum utilization figures over the expected life of each project, an estimate of future recreational benefits can be gained using methods similar to those shown on page F-3 where an expected utilization factor of 80% was chosen for the present usage of Sherod Park and City Beach. By assuming the average maximum utilization factor in the previous table for "peak" day usage, and a value of one-third the "peak" day factor for "non-peak" day usage, estimates of yearly recreational benefits can be made following the reasoning on page F-2 (100 day summer season, 26 "peak" days, 52 "non-peak" days).

Using these methods, the following recreational benefits apply to the various erosion mitigation alternatives proposed.

TABLE F-7

RECREATIONAL BENEFITS

ALTERNATIVE	(1) AVERAGE "PEAK" UTILIZATION	(2) AVERAGE "NON-PEAK" UTILIZATION	(3) Annual Beach Area Gain, SF		(4) Total Value Of Annual Beach User Gain		TOTAL
			SHEROD PARK	CITY BEACH	SHEROD PARK	CITY BEACH	
I	75%	25%	14890	7260	$22,583	$ 9,438	$32,021
II	55%	18%	27890	7260	30,794	6,871	37,665
III	55%	18%	27890	7260	30,794	6,794	37,665
IV	80%	27%	1890	7260	3,073	10,118	13,191

(3): Area Gain is for both beach construction and erosion prevention.

$$(4) = \left((3)/75\ \text{SF/User} \times \frac{2\ \text{Users}}{\text{day}} \times (1) \times 26\ \frac{\text{Peak Days}}{\text{year}} + (3)/75\ \text{SF/User} \times \frac{2\ \text{Users}}{\text{day}} \times (2) \times 52\ \frac{\text{Non Peak Days}}{\text{year}} \right) \times \begin{cases} \$1.75, & \text{Sherod Park} \\ \$1.50, & \text{City Beach} \end{cases}$$

In Table F-4, the average annual recreational loss due to the existing erosion along the study reach was computed to be $3,109. Because only 29% of this loss is attributable to the Federal navigation structures, the actual loss that can be applied to the Section 111-type mitigation actions is $902. This requires a reduction in the recreational benefits derived in Table F-7 as shown in Table F-8.

F-12

TABLE F-8

ACTUAL RECREATIONAL BENEFITS

ALTERNATIVE	(1) TOTAL RECREATIONAL BENEFIT	(2) TOTAL BENEFIT FOR SHORE PROTECTION (FROM TABLE F-4)	(3) SHORE PROTECTION BENEFIT APPLICABLE TO SECTION 111 MITIGATION*	BENEFIT DUE TO NEW BEACH CONSTRUCTION	ACTUAL RECREATIONAL BENEFIT, (1) - (2) + (3)
I	$32,021	3,109	902	28,912	$29,814
II	37,665	3,109	902	34,556	35,458
III	37,665	3,109	902	34,556	35,458
IV	13,191	3,109	902	10,082	10,984

*(3) - 29% x (2)

TETRA TECH INC. PASADENA, CALIF	SUBJECT RESIDENTIAL LAND LOSS TO 2023 A.D., CONDITIONS 2 & 3	PROJECT
	COMPUTED P.E.G. CHECKED	FILE NO
		DATE PAGE OF PAGES

EXPECTED RESIDENTIAL LAND LOSS

EXPECTED BLUFF LOSS = 209,500 SF. (FROM PAGE D-2)

UNIT VALUE = $2.25 / SF (1980 VALUE BASED ON REALTY INFORMATION)

VALUE OF BLUFF LOSS TO 2023 A.D. = $471,375

VALUE OF AVERAGE ANNUAL RESIDENTIAL LAND LOSS = $9428.

TETRA TECH INC.
PASADENA, CALIF

SUBJECT: FUTURE LOSS COMPUTATION — STRUCTURES: WEST SIDE VERMILION R.
COMPUTED: SEG
CHECKED:
PROJECT: TC 3319-02
FILE NO
DATE ___ PAGE ___ OF ___ PAGES

PHOTO ANALYSIS INDICATES THAT A NUMBER OF STRUCTURES WILL BE UNDERMINED WITHIN 50 YEARS IF NO ACTION IS TAKEN TO EFFECT SHORE PROTECTION. THESE STRUCTURES INCLUDE

	YEAR THAT BLUFF RECEDES TO WITHIN TEN FEET OF BLUFF	TYPE OF STRUCTURE	VALUE OF LOSS (1980)	COST OF PROTECTION (1980)
1	1980	SMALL Cottage	$48,000 A.	$35,000 D.
2.	1980	MARINE MUSEUM	400,000 B.	35,000
3.	1994	LARGE HOUSE	121,000 C.	35,000
4	1994	LARGE HOUSE	121,000	35,000
5.	2009	LARGE HOUSE	121,000	35,000
6	2015	LARGE HOUSE	121,000	35,000

FOOTNOTES:

A. SMALL COTTAGE REPLACEMENT COST $= 1200\,ft^2 \times \$40/ft^2 = \$48{,}000$

B. ESTIMATED VALUE

C. HOUSE REPLACEMENT COST $= 2200\,ft^2 \times \$55/ft^2 = \$121\,000$

D. COST OF ROCK REVETMENT $= \$350/LF \times 100\ LF/\_ = \$35\,000$
(COMPUTATION OF \$350/LF COST IS BASED ON DESIGN, P. E-37, WITH NO ROADWAY).

ASSUME: THE RATIONAL HOMEOWNER WILL CHOOSE TO PROTECT HIS STRUCTURE VIA SHORE REVETMENT RATHER THAN LOSE HIS STRUCTURE TO THE LAKE. IF A HOMEOWNER CANNOT AFFORD THE COST OF PROTECTION, HE WILL SELL THE HOME TO SOMEONE WHO CAN.

TETRA TECH INC.

PASADENA, CALIF

SUBJECT Cost of Private Bluff Protection

COMPUTED PEG CHECKED

PROJECT TC3319

FILE NO

DATE PAGE OF PAGES

COST OF BLUFF PROTECTION

IF HOMEOWNERS CHOOSE TO FORTIFY THEIR PROPERTY A REASONABLE COST ESTIMATE IS NECESSARY FOR THE COST OF SUCH PROTECTION

THE BULKHEAD DESIGN SHOWN BELOW YIELDS AN EXPECTED VALUE FOR BLUFF REVETMENT ... THE ANTICIPATED METHOD OF BLUFF PROTECTION. THE UNIT COST OF THE REVETMENT CAN BE ESTIMATED USING THE EARLIER COST ESTIMATE FOR THE REVETMENT DESIGNED FOR MITIGATION OF ALTERNATIVE IV

COST/LF

MATERIAL	UNIT	AMOUNT	UNIT COST	COST
CORE	CY	1.44	$27	$39
UNDERLAYER	TON	0.92	40	37
ARMOR STONE	TON	3.2	44	141
				217
			CONTINGENCY (15%)	33
			SUBTOTAL	250
			ENGINEERING / DESIGN (20%)	50
			SUPERVISION / INSPECTION (6%)	15
			OVERHEAD (5.6%)	14

UNIT COST → $329/LF

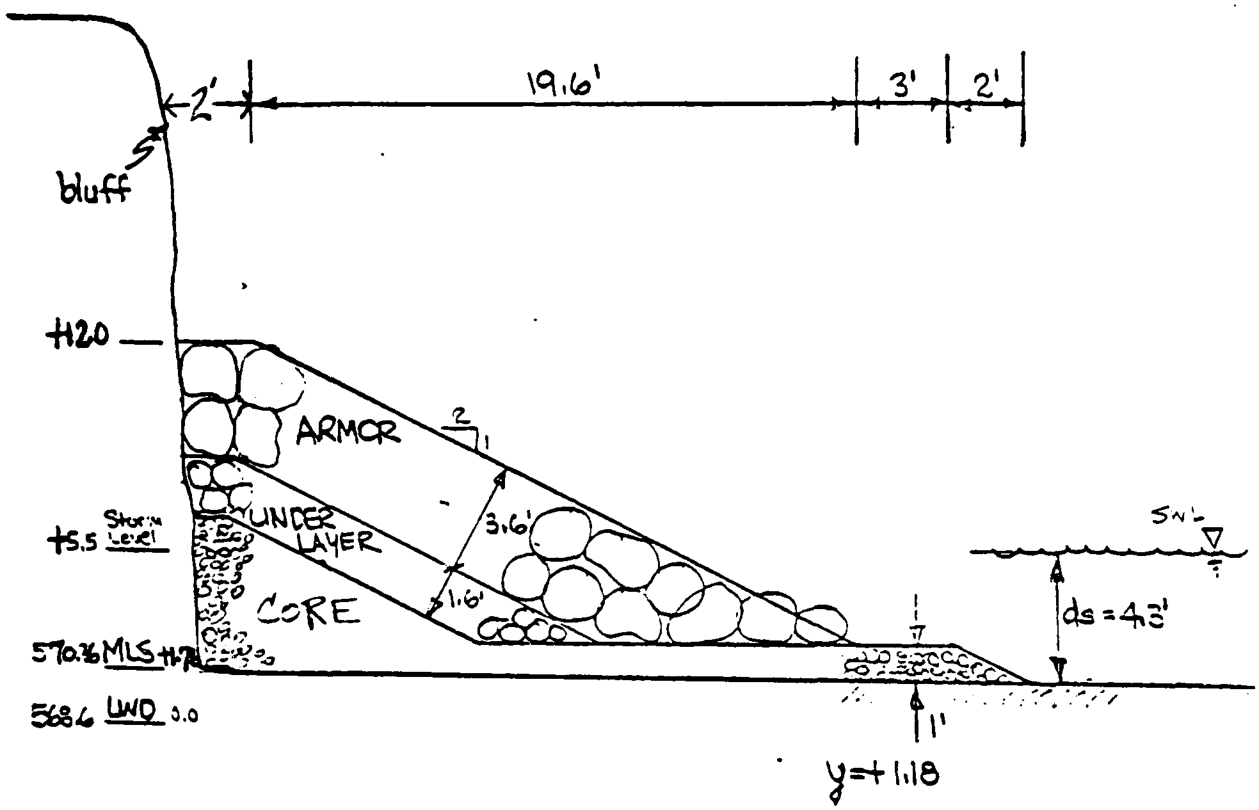
THEREFORE, ASSUME $350/LF OF REVETMENT

ASSUME A 100 FOOT AVERAGE LAKE FRONTAGE

TETRA TECH INC.
PASADENA, CALIF.

SUBJECT: COST OF PRIVATE BLUFF PROTECTION
COMPUTED: P.S.A. CHECKED:
PROJECT: TC 3319
FILE NO:
DATE: PAGE: OF: PAGES

DESIGN OF REVETMENT FOR PROTECTION OF PRIVATE PROPERTY



VOLUME COMPUTATIONS WERE TAKEN FROM THOSE OF A SIMILAR STRUCTURE SHOWN PREVIOUSLY ON PAGE E-37

ITEM	Volume/LF	Volume/100' FRONTAGE
CORE	1.44	144 C.Y
UNDERLAYER	0.92	92
ARMOR STONE	3.20	320 C.Y

TETRA TECH INC.
PASADENA, CALIF

SUBJECT Benefits Calculation
Structures West Side
COMPUTED ____ CHECKED ____

PROJECT TC 3319-02
FILE NO ____
DATE ____ PAGE ____ OF ____ PAGES

THEREFORE, THE FUTURE EXPENDITURES FOR SHORE PROTECTION CAN BE EVALUATED IN TERMS OF CONVERSION TO A "PRESENT WORTH" (PW)

$$PW = A\,(\text{pwf}' \text{ @ } 7\tfrac{1}{3}\% \text{ for "n" years}) = A\,(\text{pwf}'\ 7\tfrac{1}{3}\%\text{-}n)$$

where A = 1980 COST OF PROTECTIVE STRUCTURE = \$35,000

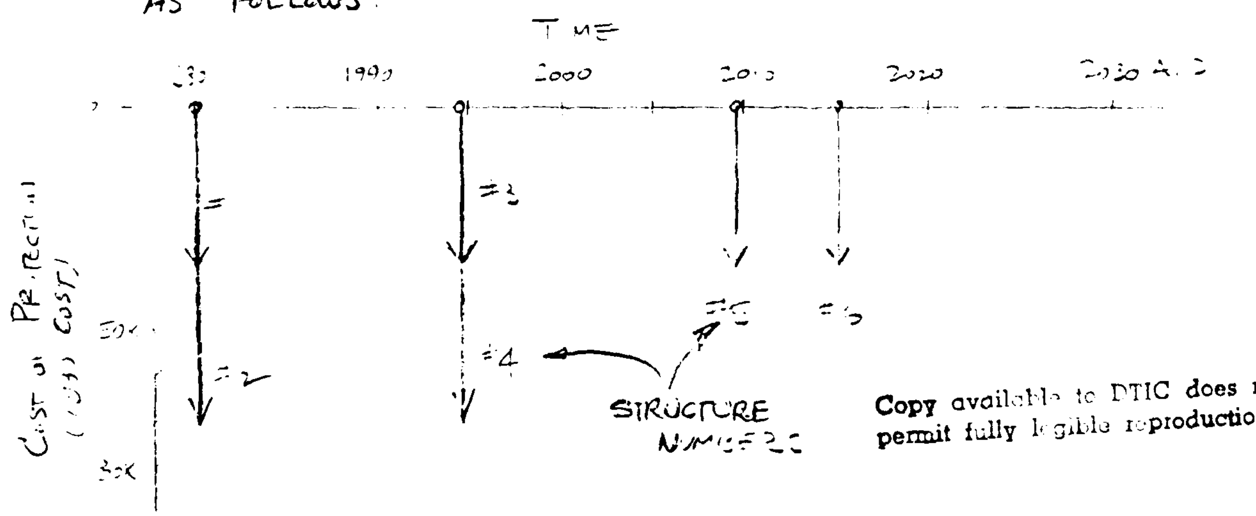
pwf' = SINGLE PAYMENT PRESENT WORTH FACTOR

$$= 1/(1+i)^n$$

i = ANNUAL INTEREST RATE

n = NUMBER OF YEARS BETWEEN EXPENDITURE AND PRESENT (1980)

THUS, FUTURE STRUCTURAL LOSSES CAN BE EXPRESSED GRAPHICALLY AS FOLLOWS:



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FUTURE EXPENDITURES FOR SHORE PROTECTION TO AVOID LOSS OF THREATENED STRUCTURE

F-18

TETRA TECH INC.
PASADENA, CALIF

SUBJECT: Benefit Computation Structures [illegible] Vermilion
COMPUTED: [illegible] CHECKED
PROJECT: TC 3319-02
FILE NO
DATE PAGE OF PAGES

TO CONVERT TO "PRESENT WORTH" (1980):

(A) STRUCTURE NO.	(B) COST OF PROTECTION	(C) YEAR OF PROTECTION	(D) PRESENT WORTH Factor *	PRESENT WORTH
1	$35,000	1930	1.0	$35,000
2	35,000	1930	1.0	35,000
3	35,000	1994	0.3815	13,353
4	35,000	1994	0.3815	13,353
5	35,000	2009	0.1359	4757
6	35,000	2015	0.0899	3147

TOTAL "PRESENT WORTH" = $104,610

* $1/(1+i)^n$
where $i = 7\frac{1}{3}\%$
$n = (C) - 1980$

NOW AMORTIZE PRESENT VALUE OF FUTURE LOSS OVER EXPECTED 50-YEAR PERIOD TO ACHIEVE ANNUAL COST.

ANNUAL COST = PRESENT WORTH x CRF ** = $104,610 x 0.0736

$\boxed{\text{ANNUAL COST} = \$7,700}$

**"CRF" = CAPITAL RECOVERY FACTOR = $\frac{i(1+i)^n}{(1+i)^n - 1}$

for $i = 7\frac{1}{3}\%$, $n = 50$ YRS, CRF = 0.0736

TABLE F-9

TOTAL BENEFITS FOR MITIGATION ALTERNATIVES

ALTERNATIVE	ANNUAL COST	SAVINGS OF RESIDENTIAL LAND*	SAVINGS OF RESIDENTIAL STRUCTURES*	SAVINGS OF EXISTING RECREATION*	BENEFITS OF ADDITIONAL RECREATIONAL RESOURCES	TOTAL BENEFITS	BENEFITS COST
I	$45,630	$9,428	$7,700	$3,109	$28,912	$34,781	0.76
II	98,200	9,428	7,700	3,109	34,556	40,425	0.41
III	85,220	9,428	7,700	3,109	34,556	40,425	0.47
IV	498,000	9,428	7,700	3,109	10,082	15,951	0.032

* These savings must be decreased to 29% of the total value shown because the Federal navigation structures are responsible for only 29% of the ongoing erosion.

F-20

ATTACHEMENT 1
ECONOMIC REEVALUATION

WEST SIDE OF VERMILION HARBOR PIERS
ECONOMIC REEVALUATION

Future losses of shorefront acreage are determined based on the bluff and shoreline change analysis conducted by Tetra Tech (final report, July 1980). Damages are calculated under existing conditions ("No Action" alternative) and under four mitigation alternatives. The differences in damages under a mitigation alternative and damages under the "No Action" alternative are NED benefits to the mitigation alternatives.

Damage categories included in this evaluation are residential land loss, public land loss, residential and public structure damages, and recreational beach value loss. In addition to damage prevented benefit categories, the proposed mitigation alternatives would provide additional public recreational beach area for which a benefit to the recreational value added is calculated.

Residential Land Loss

Existing long-term erosion trends indicate that 4,190 square feet/year of residential land is currently subject to erosion west of the Marine Museum property (Profile No. 78) extending west to Sherod Park (Profile No. 19). Local realty sources provided market value information for average lakefront lots in Vermilion. An average lot (90 feet X 200 feet) has a market value of $40,000 (1980 prices). This equates to approximately $2.25 per square foot. Therefore, total average annual residential land loss damages are calculated as $9,430 per year.

Public Land Loss

The bluff and shoreline change analysis indicates that long-term erosion will continue along two public properties, the bluff fronting Sherod Park (Profiles 6 through 18) and the Vermilion City Beach and Marine Museum property (Profiles 79-84). Though Sherod Park bluff presently erodes an average of 1,890 square feet per year, Sherod Beach fronting the bluff remains relatively stable as a result of bluff erosion nourishment. Therefore, public land loss damages are determined for the eroding bluff at Sherod Park. Losses to Vermilion City Beach are addressed under recreational beach losses.

Ideally, land loss damages at Sherod Park are measured by the loss in the value of recreation or other value to the public that the park provides. However, this public value is difficult to calculate. Therefore, as a proxy land loss damages are estimated as the residential market value ($2.25/square foot). The rationale for this assumption is that the public value of land can be no less than the residential market value of similar lakefront land in the locality, for if it was, it would be in the public's best interest to rezone the land as residential and sell it to developers. Therefore, total average annual public land loss damages are $4,250.

Residential and Public Structure Damages

Six structures on the west side of Vermilion are identified as being damaged in the 50-year project evaluation period. They include one small cottage with a replacement value of $48,000, four large houses with average replacement values of $121,000 each and the Marine Museum, valued at $400,000 for replacement. Average annual damages are calculated using the assumption that rational property owners will choose to protect their structures via shore revetment rather than lose their structures to the lake if the cost of revetment is less than the value of the structure. Total average annual structure damages for the six structures are $8,080. The calculation is presented in Table 1.

Recreational Beach Loss

Erosion damages to existing recreational beach activities are determined for Vermilion City Beach. The approximate dimensions of this beach are 20 feet (at long-term MSL 570.36 IGLD) and 220 feet length providing a usable beach area of 4,400 square feet.

The annual recreational value of this beach is calculated based on the following assumptions:

(a) The beach is utilized to capacity on peak days.

(b) Attendance on nonpeak days is one-third peak day attendance.

(c) Twenty-six peak days and 52 nonpeak days per season are used in this analysis.

(d) Analysis uses a 2.0 turnover rate; 75 square feet/person space standard.

(e) The value for each beach visit is $1.50/person (calculated in Tetra Tech, June 1980 Report).

Annual recreational value at Vermilion City Beach is $7,630. Bluff and shoreline change analysis determined that the annual beach loss is 60 square feet per year along Profile Nos. 79 through 84. This equates to a 3,000 square foot loss over the 50-year evaluation period. The annual recreational value in year 2032 is calculated to be $2,430. The average annual damage of this beach loss is $1,010.

Total Average Annual Damages

Average annual damages under existing conditions ("No Action" alternative) are summarized in Table 2.

Table 1 - Structure Damages

Number	Type of Structure	Replacement Value	Cost of Protection	Year that Bluff Recedes to Within 10 Feet of Structure (1) (Year)	Year that Bluff Recedes to Within 10 Feet of Structure (1) (Project Year)	Present Worth Factor (7-1/8%)	Present Worth (1982)
		$	$				$
1	Small Cottage	48,000	35,000	1980	-2	1.0	35,000
2	Marine Museum	400,000	35,000	1980	-2	1.0	35,000
3	Large House	121,000	35,000	1994	12	.4378	15,323
4	Large House	121,000	35,000	1994	12	.4378	15,323
5	Large House	121,000	35,000	2009	27	.1559	5,457
6	Large House	121,000	35,000	2015	33	.1032	3,612
					Total Present Worth		109,715
					Capital Recovery Factor		.07361
					Average Annual Damage		8,076

(1) Base year of project is 1982.

Table 2 - Average Annual Damages Existing Conditions

	$
Residential Land Loss	9,430
Public Land Loss (Sherod Park Bluff)	4,250
Structure Damages	8,080
Recreational Beach Loss (City Beach)	1,010
Total Average Annual Damages	22,770

Evaluation of Mitigation Alternatives

Four alternatives are evaluated in this analysis. For a detailed description of these alternatives, refer to the Tetra Tech Report, July 1980.

Residential Land Loss Prevention Benefit

Under Alternative 1, residential land will be protected by the implementation of a 20-foot wide beach which will last 20 years (until 2002). At that time, erosion will continue at a natural rate of 1 foot per year or 2,993 square feet per year. Under this alternative, average annual residential land loss would be reduced to $1,530, and the residential land loss prevention benefit is $7,900.

Under Alternatives 2, 3, and 4, residential land loss is completely eliminated and the average annual land loss prevention benefit with the three alternatives is $9,430.

Public Land Loss Prevention Benefit (Sherod Park)

Public land loss damages at Sherod Park are calculated under Alternative 1 similar to residential land loss damages. Again, a 20-foot wide protective beach with a design life of 20 years will protect Sherod Park bluff for 20 years (until 2002). The natural erosion rate at this time will cause the continuation of erosion at Sherod Park at one foot per year or 1,350 square feet per year. The average annual public land loss is therefore $690. Average annual public land loss prevention benefit for Alternative 1 is $3,650. Under Alternatives 2, 3, and 4, public land loss at Sherod Park is eliminated yielding an average annual benefit of $4,250.

Recreational Beach Loss Prevention Benefits

All of the four proposed mitigation alternatives provide for beach restoration at Vermilion City Beach and the implementation of a groin located just west of the beach. These features will prevent future damages to the existing beach. Therefore, under all four alternatives the average annual recreation beach loss prevention benefit is $1,010.

Recreational Beach Value Added

All four mitigation alternatives provide additional publicly accessible beach area. One feature, included in all four alternatives, will provide for an additional 7,200 square feet of beach at Vermilion City Beach. A second feature will add 26,000 square feet of publicly accessible beach area to the Sherod Park Beach under Alternatives 1, 2, and 3. The recreational value added for these features was calculated by (1) projecting demand for swimming within the study area for the 50-year evaluation period; (2) determining the recreational beach supply (area) of competitive publicly accessible beaches in the study area; (3) allocating demand to each of the publicly accessible beaches.

Swimming Demand

The origin area for swimming demand was assumed to include three townships adjacent to the project site. No larger area was evaluated since the existing competitive and the proposed beaches are considered local beaches not attracting more distant population areas. The three townships used in the analysis are Vermilion, Brownhelm, and Florence. Ohio SCORP Planning Region 4b household participation rate (5.22) is used to determine peak demand for swimming. Average household size for Ohio in 1980 (2.94) is used to determine the individual participation rate. Future decadal population projections for the three township area was estimated by applying the historical annual compound growth rate from 1970 to 1980. These projections are presented in Table 3.

Table 3 - Population Projections for the Demand Origin Area

Project Year	Year	Population Projection (1)
0	1982	19,675
10	[illegible]	24,369
20	2002	30,183
30	2012	37,383
40	2022	46,302
50	2032	57,348

(1) 1980 population in demand origin area is 18,851; annual compound growth rate is 2.16 percent.

The individual peak swimming participation rate is 1.78. The projected annual peak swimming demand by decade is shown in Table 4.

Table 4 - Projected Annual Peak Swimming Demand in Demand Origin Area

Project Year	Projected Annual Peak Swimming Demand
0	35,021
10	43,377
20	53,726
30	66,542
40	82,418
50	102,079

Swimming Supply

Four existing competitive beaches have been identified in the study area that are publicly accessible. They are Linwood Beach, Showsee Park Beach, the existing Vermilion City Beach, and the existing Sherod Park Beach. Beach areas by beach and the percentage distribution is presented in Table 5.

Table 5 - Publicly accessible Beach Supply

Beach	Area (1) (square feet)	Percentage Area of Total
Linwood	371,448	81.6
Showsee	24,300	5.3
City (existing)	4,400	1.0
Sherod (existing)	21,766	4.8
City (proposed)	7,200	1.6
Sherod (proposed)	26,000	5.7
Total	455,114	100.0

(1) Beach areas are calculated with lake level at the long-term MSL (570.36 IGLD)

Demand Allocation

Projected annual peak demand is allocated to the proposed recreational beach based on the percentage of beach area provided. This allocation is shown in Table 6.

Table 6 - Projected Annual Peak Demand at Proposed Beaches

Project Year	Annual Peak Demand Allocation to Proposed Beaches: Vermilion City Beach			Sherod Park Beach		
	Peak(1)	Nonpeak(2)	Total	Peak(1)	Nonpeak(2)	Total
0	560	187	747	1,996	665	2,661
10	694	231	925	2,472	824	3,293
20	860	287	1,147	3,062	1,021	4,083
30	1,065	355	1,420	3,793	1,264	5,057
40	1,335	445	1,780	4,755	1,585	6,340
50	1,633	544	2,177	5,819	1,940	7,759

(1) Annual peak demand estimates are determined by multiplying the percentage beach area supply in the study area and the total annual peak demand in the demand origin area (proposed City Beach - 1.6 percent, proposed Sherod Park Beach - 5.7 percent).

(2) Annual nonpeak demand is assumed to be one-third annual peak demand.

Evaluation of Alternatives

The recreational value added varies under each of the proposed mitigation alternatives. The average annual equivalent of the recreational value added under Alternatives 2 and 3 is $7,980 - proposed City Beach $1,550; proposed Sherod Park Beach $6,430. Under Alternative 4, there is no beach restoration at Sherod Park Beach and therefore, the average annual equivalent of recreational value added is taken for City Beach restoration only - $1,550. Under Alternative 1, the feature providing a restored beach at Sherod Park has a design life of 20 years (until 2002) and the average annual equivalent of the recreational value added for the proposed Sherod Park Beach is $4,120. The average annual benefit for the proposed City Beach is $1,550 and the total recreational value added under Alternative 1 is $5,670.

Summary of Damages and Benefits

Summaries of damages and benefits are presented in Tables 7 and 8.

Table 7 - Average Annual Damage Summary

Alternative	Structures	Land Loss Residential	Land Loss Public	Recreation Existing	Total
	$	$	$	$	$
No Action	8,080	9,430	4,250	1,010	22,770
Alternative 1	2,980	1,530	690	0	5,200
Alternative 2	0	0	0	0	0
Alternative 3	0	0	0	0	0
Alternative 4	0	0	0	0	0

Table 8 - Average Annual Benefit Summary

Alternative	Structures	Land Loss Residential	Land Loss Public	Recreation Existing	Recreation Value Added	Total
	$	$	$	$	$	$
Alternative 1	5,100	7,900	3,650	1,010	5,670	23,340
Alternative 2	8,080	9,430	4,250	1,010	7,980	30,750
Alternative 3	8,080	9,430	4,250	1,010	7,980	30,750
Alternative 4	8,080	9,430	4,250	1,010	1,550	24,320

Benefit-Cost Comparison

Total average annual benefits and costs as well as resultant net benefits and benefit-cost ratios by alternative are shown in Table 9.

Table 9 - Benefit-Cost Comparison

	Total Average Annual Benefits	Total Average Annual Costs	Net Benefits	Benefit-Cost
	$	$	$	
Alternative 1	23,340	45,630	-22,290	.51
Alternative 2	30,750	98,200	-67,450	.31
Alternative 3	30,750	85,220	-54,470	.36
Alternative 4	24,320	498,000	-473,680	.05

Subject VERMILION HBR. SEC 111 (JULY 80, TETRA TECH)
Computation of STRUCTURE LOSSES, WEST SIDE VERMILION P. F15
Computed by JON BROWN Checked by [illegible] Date 6 OCT 81

* COMPUTE EROSION RATES FROM 1973; USE 1982 AS BASE YEAR FOR EVALUATION
JULY 1980 PRICE LEVEL; 7 1/8 % INTEREST RATE

WITHOUT PROJECT: CONDITIONS THAT WOULD HAVE OCCURRED IN THE ABSENCE OF FEDERAL NAVIGATION IMPROVEMENTS. USE NATURAL EROSION RATE 1.0 FT/YEAR

WITH PROJECT: PRESENT CONDITIONS WITH NAVIGATION IMPROVEMENTS IN PLACE. EROSION RATE 1.4 FT/YR

SEE TETRA TECH REPORT JULY 1980 PAGE 6-1, AND PAGES F-15-19 AND P 5-6.

I WITH PROJECT DAMAGES

NO.	TYPE OF STRUCTURE	REPLACEMENT VALUE $	COST OF PROTECTION $	(1.4 FT/YR)* YEAR BLUFF WITHIN 10 FT OF STRUCTURE (YEAR)	(PR YR)	PRESENT WORTH FCT (7 1/8 %)	(1982) PRESENT WORTH $
1.	SMALL COTTAGE	48,000	35,000	1980	-2	1.0	35,000
2.	MARINE MUSEUM	400,000	35,000	1980	-2	1.0	35,000
3.	LARGE HOUSE	121,000	35,000	1994	12	.4378	15,323
4.	LARGE HOUSE	121,000	35,000	1994	12	.4378	15,323
5.	LARGE HOUSE	121,000	35,000	2009	27	.1559	5,457
6	LARGE HOUSE	121,000	35,000	2015	33	.1032	3,612

TOTAL PRESENT WORTH = 109,715
C.R.F. (7 1/8, 50) .07361
AVERAGE ANNUAL DAMAGE $8076

II WITHOUT PROJ DAMAGES

NO.	COST OF PROTECTION $	NATURAL RATE: 1.0 FT/YR* YEAR BLUFF WITHIN 10 FT OF STRUCTURE (YEAR)	(PROJ YR)	P.W. FCT 7 1/8 %	(1982) PRES WORTH $
1	35,000	1983	1	.9335	32,673
2	35,000	1983	1	.9335	32,673
3	35,000	2002	20	.2525	8,838
4	35,000	2002	20	.2525	8,838
5	35,000	2023	41	.0595	2,083
6	35,000	2032	50	.0320	1,120

TOTAL P.W. $ 86,225
C.R.F. .07361
A.A.D. = $6,347

TOTAL AVE ANNUAL DAMAGES ATTRIBUTED TO FEDERAL PROJECT
$8,076 - $6,347 = $1,729

Subject VERMILION HBR SEC 111 (JULY 80, TETRA TECH)
Computation of STRUCTURE LOSS/ PREVENTION BENEFITS ALT. 1 p6.3-6.8
Computed by JON BROWN Checked by P.M. 10/ 0 Date 9 OCT 81

UNDER ALT. 1, THE MARINE MUSEUM GROIN AND 20'x360' CITY BEACH RESTORATION WILL HALT EROSION COMPLETELY BETWEEN THE GROIN AND THE WEST PIER FOR THE ENTIRE PROJ EVALUATION PERIOD. THIS WILL PREVENT STRUCTURE LOSS/DAMAGE FOR THE MARINE MUSEUM ...

ALT 1 ALSO PROVIDES FOR RESTORATION OF BEACH 7100 FT BY 20 FEET FROM THE GROIN TO COEN RD. ALSO ANNUAL REPLENISHMENT OF 2123 CU YD. OF SAND IN THIS AREA WILL RETARD EROSION FROM THE AGGREVATED RATE OF 1.4 FT/YR TO THE NATURAL RATE OF 1.0 FT/YR.

THIS WILL RESULT IN A DELAY OF STRUCTURE LOSS/DAMAGE FOR 20 YEARS, THEN THE DAMAGES ASSOCIATED WITH THE NATURAL RATE OF EROSION WOULD OCCUR

STRUCTURE DAMAGES WITH ALTERNATIVE 1

III

NO.	STRUCTURE	COST OF PROTECTION (DAMAGE)	YEAR BLUFF IS WITHIN 10 FT. OF STRUCT. (YEAR) [1][2]	(PR YR)	PRES. WORTH FACTOR (7 1/8%)	(1982) PRESENT WORTH
1	SMALL COTTAGE	35,000	1980	-2	1.0	35,000
2	MARINE MUSEUM	— [2]	—	—	—	—
3	LARGE HOUSE	35,000	2019	37 [3]	.0784	2,744
4	LARGE HOUSE	35,000	2019	37 [3]	.0784	2,744
5	LARGE HOUSE	35,000	2040	58 [3]	— [4]	—
6	LARGE HOUSE	35,000	2048	66 [3]	— [4]	—
					TOTAL PW	40,488
					C.R.F.	.07361
						2980

1) SEE TETRA TECH JULY 80 pp F15-19
2) SEE EXPLANATION ABOVE.
3) SEE WORKSHEET 6 OCT 81, p1 of 16 I. PROJ YR. X 1.4 FT/YR ÷ 1.0 FT/YR + 20 YEARS
4) BEYOND PROJECT EVALUATION PERIOD

AVE ANNUAL STRUCTURE DAMAGE PREVENTION BENEFIT = $8,076 − $2,980
$5,096

Subject VERMILION HBR SEC 111 (JULY 80 TETRATECH)
Computation of STRUCTURE LOSS PREVENTION BENEFITS ; ALT 2, 3, AND 4 p 6-8 THRU p 6-18
Computed by JON BROWN Checked by [illegible] Date 9 OCT 81

IV UNDER ALT 2 - SAME FEATURES AS ALT 1 PLUS BEACH NOURISHMENT 7,384 CU YD / YEAR TO OFFSET TOTAL EROSION PROCESSES.

STRUCTURE DAMAGES WITH ALTERNATIVE 2 WOULD BE COMPLETELY ELIMINATED.

∴ AVERAGE ANNUAL STRUCTURE DAMAGE PREVENTION BENEFIT IS \$ 8,076 - 0 = \$ 8,076

V UNDER ALT 3 - SAME FEATURES AS ALT 1 PLUS 11 SHORT (85 FT LONG) GROINS LOCATED BETWEEN COEN RD AND MARINE MUSEUM GROIN PLUS ANNUAL BEACH NOURISHMENT OF 3692 CU YD / YR.

STRUCTURE DAMAGES WITH ALTERNATIVE 3 LIKE ALT 2 WOULD BE COMPLETELY ELIMINATED AND THEREFORE AVE ANNUAL STRUCTURE DAMAGE PREVENTION BENEFIT IS \$ 8076

VI UNDER ALT 4 - CONSTRUCTION OF 210 FT MARINE MUSEUM GROIN (SAME AS ALT 1); 20 FT X 360 FT BEACH RESTORATION EAST OF GROIN (SAME AS ALT 1); CONSTRUCTION OF REVETMENT FOR BLUFF PROTECTION FROM GROIN TO COEN ROAD.

LIKE ALTS 2 + 3 STRUCTURE DAMAGES ARE ELIMINATED AND STRUCTURE DAMAGE PREVENTION BENEFIT IS \$ 8,076

Subject VERMILION HBR SEC 111 (JULY 80, TETRA TECH)
Computation of RESIDENTIAL AND PUBLIC LAND DAMAGE, WEST VERMILION
Computed by JON BROWN Checked by [illegible] 10/20 Date 9 OCT 81

VII RESIDENTIAL LAND LOSS (SEE P D-1 + D-2)

RESIDENTIAL PROFILES # 19-78 AND # 85-88 (NO EROSION)

RESIDENTIAL LAND LOSS FOR 50 YEARS = 209,500 SF
AVERAGE RES. LAND LOSS = 209,500/50 = 4190 SQFT/YR
AVERAGE RES. VALUE OF LAND = $2.25/SQFT 1/

TOTAL AVERAGE ANNUAL RESIDENTIAL LAND LOSS DAMAGES ARE

4190 SQFT/YR x $2.25/SQFT = $9,428/YR

* NOTE, SINCE AGGRAVATED RATE OF EROSION IS 1.4 FT/YR 2/
AND NATURAL RATE OF EROSION IS 1.0 FT/YR 2/

DAMAGES ASSOCIATED UNDER NATURAL EROSION IS $\frac{1.0 FT/YR}{1.4 FT/YR}$ x 4190 SQFT/YR

OR 2,993 SQFT/YR x $2.25 = $6,734/YR —

DAMAGES ASSOCIATED TO FED. NAVIGATION INDUCED EROSION IS $\frac{1.4-1.0}{1.4}$ x 4190

OR 1197 SQFT/YR x $2.25 = $2694/YR

VIII 1. PUBLIC LAND LOSS (SEE P D-3) (SHEROD PARK) PROFILES # 6-18

SHEROD PARK LAND LOSS FOR 50 YEARS = 94 500 SQFT
AVE PARK LAND LOSS 94,500/50 = 1890 SQFT/YR.
AVE. ANNUAL PARK LAND LOSS = 1,890 SQFT/YR x $2.25/SQFT 4/ = $4253/YR
DAMAGE ASSOCIATED WITH NATURAL EROSION = $\frac{1.0}{1.4}$ x 1890 x $2.25 = $3038
DAMAGE ASSOCIATED WITH FED NAVIGATION INDUCED EROSION = $\frac{1.4-1.0}{1.4}$ x 1890 x 2.25 = $1215
2. PUBLIC LAND LOSS (SEE P D-3) (VERMILION CITY BEACH 5/ & MARINE MUSEUM (NP))

1/ SEE P 5-7 AND F-14: 1980 VALUE BASED ON LOCAL REALTY INFORMATION.
AVE LAKE FRONT LOTS 90' x 200' HAVE 1980 MARKET VALUE OF $40,000. $40000 ÷ 18,000 SQFT = $2.25/SQFT
2/ SEE PAGE 6-1
3/ SEE PAGE 4-1
4/ THE PUBLIC VALUE OF SHEROD PARK CAN BE NO LESS THAN THE VALUE OF RESID LAND SINSE IF IT WERE VALUED LESS IT WOULD BE IN THE PUBLIC'S BEST INTEREST TO REZONE IT RESIDENTIAL AND SELL IT TO DEVELOPERS THEREFORE $2.25/SQFT IS USED AS A PROXY TO ESTIMATE THE RECREATION AND OTHER PUBLIC VALUE OF THE LAND LOSS.
5/ LAND LOSS FOR VERMILION CITY BEACH WILL BE EVALUATED UNDER RECREATION LOSSES p. 7 of 16

Subject VERMILION HBR SEC 111 (JULY 80, TETRA TECH) (WEST VERMILION)
Computation of RESIDENTIAL + PUBLIC LAND LOSS PREVENTION BENEFITS (7 1/8%)
Computed by JON BRAWN Checked by [illegible] Date 13 OCT 81

IX LAND LOSS DAMAGES UNDER ALTERNATIVE 1.
(SEE WORKSHEET 2 OF 16 DATED 9 OCT 81 FOR DESCRIPTION OF ALT 1)

1. RESIDENTIAL LAND LOSS : ALT 1 (PROFILE # 19-78) p. D-1-2
UNDER ALT 1 RESIDENTIAL LANDS WILL BE PROTECTED FOR 20 YEARS (UNTIL 2002) AFTER WHICH EROSION WILL CONTINUE AT NATURAL RATE (1.0FT/YR) OR 2,993 SQFT/YR[1]

AVG. ANNUAL DAMAGES (ALT 1) = 2,993 SQFT/YR · $2.25/SQFT (P.W. OF 1 PER PERIOD FOR 30 PERIODS)(P.W. OF 1 FOR 20 PERIODS)(CAPITAL RECOVERY FCT) =

$6,734 x 12.2548 x .2525 x .07361 = $1,534

AVE ANNUAL RES LAND LOSS PREVENTION BENEFITS (ALT 1) = $9,428 - $1,534 = $7,894

2. PUBLIC LAND LOSS ALT 1 (SHEROD PARK) (PROFILE #s 6-18) p D-3
UNDER ALT 1 PUBLIC LAND AT SHEROD PARK WILL BE PROTECTED FOR 20 YRS (UNTIL 2002) AFTER WHICH EROSION WILL CONTINUE AT NATURAL RATE (1.0FT/YR) OR 1,350 SQFT/YR[2]

AVG ANNUAL DAMAGES (ALT 1) = 1,350 SQFT/YR x $2.25/SQFT (P.W. OF 1 PER PERIOD FOR 30 PERIODS)(P.W OF 1 FOR 20 PERIODS)(CAPITAL RECOVERY FCT) =

$3,038 x 12.2548 x .2525 x .07361 = $692

AVG ANNUL PUBLIC LAND (SHEROD PK) LOSS PREVENTION BENEFIT (ALT 1) = $4,253 - $692 = $3,561

1) SEE WORKSHEET 4 OF 16, DATED 9 OCT 81, ITEM VII
2) SEE WORKSHEET 4 OF 16, DATED 9 OCT 81, ITEM VIII

Subject VERMILION HBR SEC 111 (JULY 80 TETRA TECH)
Computation of RESIDENTIAL & PUBLIC LAND LOSS PREVENTION BENEFITS (7½%)
Computed by JON BROWN Checked by PZM 10/20 Date 13 OCT 81

X LAND LOSS DAMAGES UNDER ALT 2,3,4 (SEE WORKSHEET 3 OF 16 DATED 9 OCT 81 FOR DESCRIPTION OF ALT 2,3,4.

RESIDENTIAL AND PUBLIC LAND LOSS IS ELIMINATED UNDER ALT 2,3,4 THEREFORE:

AVE ANNUAL LAND LOSS PREVENTION BENEFITS UNDER ALT 2,3,4 = \$9428 (RESID.) + \$4253 (PUBLIC) = \$13,681

Subject VERMILION HBR SEC 111 (TETRA TECH JULY 80)
Computation of RECREATIONAL BEACH VALUE AND DAMAGES (BASE YR 1982, i=7 1/8%)
Computed by JON BROWN Checked by [illegible] 10/20 Date 14 OCT 81

XI. DAMAGES TO RECREATIONAL EXISTING BEACH ACTIVITIES FROM EROSION ON THE WEST SIDE OF VERMILION HARBOR WERE DETERMINED FOR CITY BEACH. THOUGH THE BLUFF OF SHEROD PARK IS RECEDING FROM SHORE PROCESSES, THE BEACH FRONTING THE BLUFF IS MAINTAINED THROUGH BLUFF NOURISHMENT. (PAGE F-1)

1. THE APPROXIMATE DIMENSIONS OF CITY BEACH ARE 20 FT WIDTH (AT LONG TERM MSL) & 220 FT LENGTH (P. E-9 & P. 2-4) PROVIDING A USABLE BEACH AREA OF 4400 SQ FT

2. THE ANNUAL RECREATIONAL VALUE OF THIS BEACH IS CALCULATED USING THE FOLLOWING ASSUMPTIONS:
   a. THE BEACH IS UTILIZED TO CAPACITY ON PEAK DAYS[1]
   b. ATTENDANCE ON NON PEAK DAYS IS 1/3 OF PEAK DAY ATTENDANCE
   c. 26 PEAK DAYS AND 52 NON PEAK DAYS ARE USED IN THE ANALYSIS
   d. ANALYSIS USES A 2.0 TURNOVER RATE; 75 SQ FT/PERSON SPACE STANDARD
   e. THE VALUE FOR EACH BEACH VISIT IS $1.50/PERSON[2]

3. ANNUAL RECREATIONAL VALUE IS CALCULATED AS:

PEAK	$4400 \div 75 \times 2.0 \times 26 \times 1.50 =$	$4,576
NON PEAK	$4400 \div 75 \times 2.0 \times 52 \times 1/3 \times 1.50 =$	3,051
TOTAL		$7,627

4. ANNUAL RECREATIONAL VALUE WITH EXISTING ANNUAL AREA LOSS OF 60 SQ FT / YEAR (P. F-6) OR 3000 SQ FT IN 50 YEARS (P. D-3)

PEAK (P. YR 50):	$(4400-3000) \div 75 \times 2.0 \times 26 \times 1.50 =$	$1456
NON PEAK (P. YR 50):	$(4400-3000) \div 75 \times 2.0 \times 52 \times 1/3 \times 1.50 =$	$971
TOTAL (P. YR 50)		$2,427

TO CALCULATE THE PRESENT WORTH OF THIS NEGATIVE GROWTH (STRAIGHT LINE)

$$PW = P + \frac{P}{g}\left[\frac{g-1}{i} - \frac{1-\frac{1}{(1+i)^{g-1}}}{i^2}\right]$$

WHERE P = DIFFERENCE IN VALUES BETWEEN YEARS OF DECLINING GROWTH
g = NUMBER OF YEARS OF DECLINING GROWTH
i = PROJECT INTEREST RATE

$$5200 + \frac{5200}{50}\left[\frac{50-1}{.07125} - \frac{1-1/(1.07125)^{49}}{(.07125)^2}\right]$$

AVE ANNUAL VALUE OF NEG GROWTH = $56939 × .07361 = $4191

PW OF NEG GROWTH = $56,939 TOTAL AVE ANNUAL VALUE = $4191 + $2427 = $6618

5. AVE. ANNUAL DAMAGES TO RECREATION AT CITY BEACH = $7627 − $6618 = $1,009

1) THIS ASSUMPTION IS A LIBERAL ONE TO ENSURE ANALYSIS PROVIDES MAXIMUM BENEFITS FOR DAMAGES ELIMINATED.
2) PAGES F-3, F-4, F-5

Subject VERMILION HBR SEC 111 (TETRA TECH, JULY 80)
Computation of RECREATIONAL BEACH BENEFITS (DAMAGES PREVENTED AND FUTURE BENEFITS PROV.
Computed by JON BROWN Checked by PEM 10/20 Date 15 OCT 81

XIII 1. UNDER ALL 4 ALTERNATIVES, EXISTING RECREATIONAL DAMAGES WILL BE TOTALLY ELIMINATED. (SEE WORKSHEETS 2 OF 16, AND 3 OF 16, FOR DESCRIPTION OF ALTERNATIVES)

THEREFORE: RECREATIONAL DAMAGES PREVENTED AT CITY BEACH ARE: $ 1,009. (AVERAGE ANNUAL BENEFIT)

2. BEACH RESTORATION AT CITY BEACH UNDER ALL 4 ALTERNATIVES PROVIDES AN ADDITIONAL USABLE BEACH AREA OF 7200 SQ FT (20 FT WIDTH AT LONG TERM MSL, SEE P. E-9, AND 360 FT LENGTH (SEE P E-14). WITH THE CONSTRUCTION OF THE MUSEUM GROIN (UNDER ALL 4 ALTERNATIVES)

ANNUAL CAPACITY PROVIDED: CITY BEACH (ADDITIONAL)

ANNUAL PEAK DAY CAPACITY:	$7200 \div 75 \times 2.0 \times 26 =$	4992	PERSONS
ANNUAL NONPEAK DAY CAPACITY:	$7200 \div 75 \times 2.0 \times 52 =$	9,984	PERSONS
ANNUAL TOTAL CAPACITY:		14,976	

3. BEACH RESTORATION AT SHEROD PARK UNDER ALTERNATIVES 1, 2 AND 3 PROVIDES AN ADDITIONAL 26,000 SF (20 FT WIDTH AT 570.3) AND 1300 FT LENGTH)

ANNUAL CAPACITY PROVIDED: SHEROD PARK (ADDITIONAL)

ANNUAL PEAK DAY CAPACITY:	$26,000 \div 75 \times 2.0 \times 26 =$	18,027	PERSONS
ANNUAL NONPEAK DAY CAPACITY:	$26,000 \div 75 \times 2.0 \times 52 =$	36,053	PERSONS
ANNUAL TOTAL CAPACITY		54,080	

Subject: VERMILION HBR SEC 111 (TETRATECH JULY 80)
Computation of: RECREATIONAL VALUE ADDED UNDER MITIGATION ALTERNATIVES
Computed by: J BROWN Checked by: [illegible] 10/21/81 Date: 20 OCT 81

XII. ALL FOUR MITIGATION ALTERNATIVES PROVIDE ADDITIONAL PUBLICLY ACCESSIBLE BEACH AREA. ① RESTORATION OF CITY BEACH ADDING A 360 FT LONG 20 FT WIDE (AT MSL: 570.36) EAST OF PROPOSED MARINE MUSEUM GROIN (SEE WORKSHEET 2 OF 16 OF THIS ANALYSIS) THIS FEATURE IS INCLUDED IN ALL FOUR ALTERNATIVES. ② RESTORATION OF SHEROD PARK BEACH 1300 FT LONG BY 20 FEET WIDE (AT MSL: 570.36) THE 20 FT WIDE BEACH RESTORATION WOULD EXTEND FROM THE PROPOSED MARINE MUSEUM GROIN TO COON ROAD (7100 FT) HOWEVER ONLY THE 1300 FT FRONTING SHEROD PARK WOULD BE ACCESSIBLE TO THE PUBLIC. THIS FEATURE IS PROVIDED UNDER ALTERNATIVES 1, 2, AND 3 ONLY.

USABLE RECREATIONAL BEACH AREA: FEATURE ① 7200 SQ FT; FEATURE ② 26,000 SQ FT.

TO CALCULATE THE RECREATIONAL VALUE ADDED PROVIDED BY THESE ALTERNATIVES, ONE MUST FIRST DETERMINE OTHER RECREATION COMPONENTS INCLUDING 1. DEMAND FOR SWIMMING PROJECTED FOR FIFTY YR EVALUATION PERIOD. 2. BEACH SUPPLY (AREA) OF COMPETING PUBLICALLY ACCESSIBLE RECREATIONAL BEACHES 3. ALLOCATION OF [illegible] TO PUBLICALLY ACCESSIBLE BEACH AREAS.

1. SWIMMING DEMAND: THE ORIGIN AREA FOR SWIMMING DEMAND WAS ASSUMED TO INCLUDE 3 TOWNSHIPS ADJACENT AND CONTIGUOUS TO THE PROJECT SITE. NO LARGER AREA WAS EVALUATED SINCE THE PROPOSED BEACHES ARE CONSIDERED LOCAL BEACHES NOT ATTRACTING DISTANT POPULATION AREAS. THE THREE TOWNSHIPS INCLUDE: VERMILION TWP, BROWNHELM TWP, AND FLORENCE TWP. OHIO SCORP PLANNING REGION 4b HOUSEHOLD PARTICIPATION RATES ARE USED TO DETERMINE PEAK DEMAND FOR SWIMMING, AVG HOUSEHOLD SIZE FOR OHIO IN 1980 IS 2.94. THIS IS USED TO DETERMINE INDIVIDUAL PARTICIPATION RATE. DECADAL POPULATION PROJECTION FOR THE 3 TWP AREA WAS DETERMINED BY APPLYING THE HISTORICAL ANNUAL COMPOUND GROWTH RATE FROM 1970 TO 1980.

TWP	POPULATION (CENSUS) 1970	1980
VERMILION	8446	10,027
FLORENCE	1576	2119
BROWNHELM	5198	6705
TOTAL	15220	18,851

GROWTH RATE FACTOR = $\sqrt[10]{\frac{18,851}{15,220}} = 1.02166$ (2.16% PER ANNUM)

PROJ YEAR	YEAR	PROJECTED POPULATION (3 TWP)
0	1982	19675
10	1992	24,369
20	2002	30,183
30	2012	37,383
40	2022	46,302
50	2032	57,348

* PROJECTED POPULATION IS HIGHLY OPTIMISTIC HOWEVER A LIBERAL APPROACH IS USED TO PROVIDE THE MAXIMUM POSSIBLE BENEFIT

Subject: VERMILION HPR SEC 111 (TETRATECH, JULY 80)

Computation of: RECREATIONAL VALUE ADDED UNDER MITIGATION ALTERNATIVES

Computed by: J BROWN Checked by: DAL 10/21/81 Date: 20 OCT 81

(XII CONTINUED)

OHIO SCORP PLANNING REGION 4D HOUSEHOLD PARTICIPATION RATE (1980) = 5.22

INDIVIDUAL PEAK DAY PART. RATE = 5.22 ÷ 2.94 (AVG HOUSEHOLD SIZE: OHIO) = 1.78

PR YR	PROJECTED POPULATION OF ORIGIN AREA		PART. RATE		PROJECTED ANNUAL PEAK SWIMMING DEMAND
0	19,675	x	1.78	=	35,021
10	24,369		1.78		43,377
20	30,183		1.78		53,726
30	37,383		1.78		66,542
40	46,302		1.78		82,418
50	57,348		1.78		102,079

2) BEACH SUPPLY AREA FOR PROJECT BEACHES AND COMPETITIVE AREAS

MRI BEACH INVENTORY CONDUCTED IN 1979 WAS USED TO DETERMINE COMPETITIVE BEACHES AND BEACH AREA AT MSL. THERE 10 BEACHES LOCATED WITHIN THE STUDY AREA (FACILITY NO. 137 TO 175) HOWEVER ONLY 4 ARE PUBLICALLY ACCESSIBLE LINWOOD BEACH, SHOLLSEE BEACH (EXISTING) CITY BEACH, AND EXISTING SHERROD BEACH.

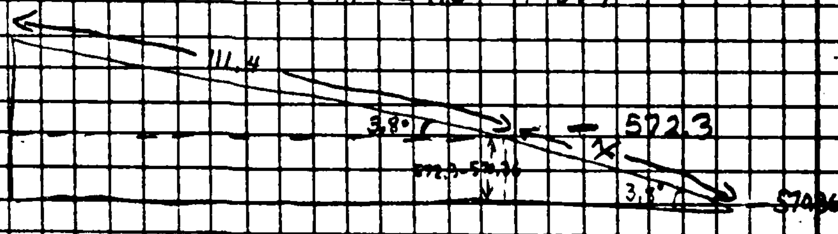
DETERMINE AVG BEACH AREA AT LONG TERM MEAN LEVEL 570.36

LINWOOD BEACH[1] LENGTH 2640 FT

	WIDTH (AT 572.3)	SLOPE
P1	86'	4°
P2	59	6°
P3	108	6°
P4	90	5°
P5	16	4°
P6	127	3°
P7	174	2°
P8	190	2°
P9	102	3°
P10	106	3°
AVG	111.4'	3.8°

AVG WIDTH @ 572.3 = 111.4'

AVG WIDTH @ 570.36 = 111.4' + (572.3 − 570.36) / sin 3.8°
= 111.4 + 29.3' = 140.7'



X = (572.3 − 570.36) ÷ sin 3.8°

AVG AREA OF LINWOOD BCH AT 570.36 (2640' x 140.7') = 371,448 SQ FT

[1] INVENTORY INFORMATION IS PROVIDED BY MRI BEACH INVENTORY FAC. NO. 137 DATED 8/8/79

Subject VERMILION HBR SEC 111 (TETRA TECH, JULY 80)
Computation of RECREATION VALUE UNDER MITIGATION ALT.
Computed by JON BROWN Checked by [illegible] Date 29 OCT 81

XII 2) CONTINUED

SHOWSEE PARK BEACH[1] LENGTH 600 FT

STATION	WIDTH (AT 572.3)	SLOPE
Pt 1	25	6°
Pt 2	29	5
Pt 3	24	7
Pt 4	19	8
Pt 5	18	6
Pt 6	18	6
Pt 7	19	6
Pt 8	24	6
Pt 9	28	7
Pt 10	27	7
AVG	23.1'	6.4°

AVG WIDTH @ 572.3 = 23.1 ft

AVG WIDTH @ 570.36 = 23.1 Ft + (572.3 - 570.36) / sin 6.4°
= 23.1 Ft + 17.4 Ft = 40.5 Ft

AVG AREA OF SHOWSEE BEACH AT 570.36 (600 x 40.5) = 24,300 SQ FT

EXISTING CITY BEACH: LENGTH 220 FT, WIDTH 20 FT, AVG AREA OF CITY BEACH AT 570.36 IS 4400 SQ FT[2]

EXISTING SHERROD PARK BEACH[3] LENGTH: 505 FT

STATION	WIDTH AT (572.2)	SLOPE
Pt 1	18'	4°
Pt 2	18	5
Pt 3	18	7
Pt 4	18	7
Pt 5	21	6
Pt 6	26	6
Pt 7	28	5
Pt 8	35	5
Pt 9	27	5
Pt 10	33	6
AVG	24.2 Ft	5.6°

AVG WIDTH AT 572.2 = 24.2 FT

AVG WIDTH AT 570.36 = 24.2 + (572.2 - 570.36) / sin 5.6°
= 24.2 Ft + 18.9 = 43.1 FT

AVG AREA AT 570.36 = (505' x 43.1') = 21,766 SQ FT

1) INVENTORY INFORMATION FROM MRI BEACH INVENTORY: FACILITY NO. 138

2) SEE WORKSHEET 7 OF 16 OF THIS ANALYSIS ITEM II 1)

3) INVENTORY INFORMATION FROM MRI BEACH INVENTORY FACILITY NO. 141

Subject VERMILION HBR SEC 111 (TETRA TECH JULY 80)
Computation of RECREATIONAL VALUE ADDED UNDER MITIGATION ALTERNATIVES
Computed by JW BROWN Checked by RAP 10/21/81 Date 20 OCT 81

XII 2) CONTINUED

BEACH RECREATION SUPPLY IN STUDY AREA (PUBLIC ACCESSIBLE BEACHES)

BEACH	AREA (AT 570.36) (SQ FT)	% OF TOTAL (AREA)
LINWOOD	371,448	81.6
SHOWSEE	24,300	5.3
CITY (EXISTING)	4,400	1.0
SHEROD (EXISTING)	21,766	4.8
CITY (ADDITIONAL)	7,200	1.6
SHEROD (ADDITIONAL)	26,000	5.7
TOTAL AREA	455,114	100.0

3) PROJECTED ANNUAL PEAK DEMAND IS ALLOCATED TO RECREATIONAL BEACHES BASED ON THE PERCENTAGE OF BEACH AREA PROVIDED

Pr Yr	STUDY AREA PROJECTED SWIMMING DEMAND (ANNUAL PEAK)	ANNUAL PEAK DEMAND ALLOCATION TO PROPOSED BEACHES: CITY BCH 1.6%	SHEROD BCH 5.7%
0	35,021	560	1996
10	43,377	694	2472
20	53,726	860	3062
30	66,542	1,065	3793
40	83,418	1,335	4755
50	102,079	1,633	5,819

	CITY BEACH			SHEROD BEACH		
Pr Yr	ANNUAL PEAK DEMAND	ANNUAL PEAK CAP	PROJ PEAK ATTEND.	ANNUAL PEAK DEMAND	ANNUAL PEAK CAP	PROJ PEAK ATTEND.
0	560	4992	560	1,996	18,027	1996
10	694	4992	694	2,472	18,027	2472
20	860	4992	860	3,062	18,027	3062
30	1,065	4992	1065	3,793	18,027	3793
40	1,335	4992	1335	4755	18,027	4755
50	1,633	4992	1633	5,819	18,027	5819

PROJECTED PEAK ATTENDANCE (ANNUAL) IS THE LESSER OF ANNUAL PEAK CAPACITY AND ANNUAL PEAK DEMAND

SEE WORKSHEET 8 OF 16 OF THIS ANALYSIS (15 OCT 81)

Subject VERMILLION HBR SEC 111 (TETRA TECH, JULY 80)
Computation of RECREATIONAL VALUE ADDED UNDER MITIGATION ALT.
Computed by JON BROWN Checked by pal 10/22/81 Date 20 OCT 81

XII 3) CONTINUED

ASSUMING NON PEAK ATTENDANCE IS 1/3 OF PEAK ATTENDANCE (SEE PAGE 7 OF 16 ITEM XI 1, b.)

PR YR	ADD'L CITY BEACH ANNUAL ATTENDANCE PEAK	NON PEAK	TOTAL	ADDITIONAL SHEROD BEACH ANNUAL ATTENDANCE PEAK	NON PEAK	TOTAL
0	560	187	747	1996	665	2661
10	694	231	925	2472	824	3296
20	860	287	1147	3062	1021	4083
30	1065	355	1420	3793	1264	5057
40	1335	445	1780	4755	1585	6340
50	1633	544	2177	5819	1940	7759

	PR YR	PROJ ATTEND	VALUE PER VISIT $	TOTAL VALUE $	INCREMENT IN VALUE $	AVE ANN EQUIV FCT 2)	P.W. OF 1/PER. FCT 2)	P.W. FCT 2)	C.R.F. 2)	AVE ANNUAL VALUE $
CITY BEACH	0	747	1.50 1)	1121	1121	—	—	—	—	1,121
	10	925	1.50	1388	267	.7397	—	—	—	197
	20	1147	1.50	1721	333	.7309	13.1406	.5025	.07361	118
	30	1420	1.50	2130	409	.7115	12.2548	.2525	.07361	66
	40	1780	1.50	2670	540	.6630	10.4919	.1269	.07361	35
	50	2177	1.50	3266	596	.4937	6.9832	.0637	.07361	10
									TOTAL	$1547
SHEROD BEACH	0	2661	1.75 3)	4657	4657	—	—	—	—	4,657
	10	3296	1.75	5768	1111	.7397	—	—	—	821
	20	4083	1.75	7145	1377	.7309	13.1406	.5025	.07361	490
	30	5057	1.75	8850	1705	.7115	12.2548	.2525	.07361	277
	40	6340	1.75	11,095	2245	.6630	10.4919	.1269	.07361	196
	50	7759	1.75	13,578	2483	.4937	6.9832	.0637	.07361	40
									TOTAL	$6,431

1) SEE WORKSHEET 7 OF 16 OF THIS ANALYSIS ITEM XI 2 C FOOTNOTE 3)

2) ANALYSIS USES 7 1/8 % INTEREST RATE, ASSUMES STRAIGHT LINE GROWTH

3) SEE TETRA TECH P. F-3, F-4, F-5

Subject: VERMILION HRR SEC 111 (TETRA TECH JULY 80)
Computation of: RECREATIONAL VALUE ADDED UNDER MITIGATION ALT.
Computed by: JON BROWN Checked by: fal 10/22/81 Date: 21 OCT 81

XII RECREATION BENEFITS

1 ALTERNATIVE 1 (A) ALL ALTERNATIVES PROVIDE FOR A RESTORED CITY BEACH AND THEREFORE $1,547 AVERAGE ANNUAL BENEFIT FOR THE ADDITIONAL BEACH

(B) FEATURE TWO OF ALT 1 PROVIDES A 20FT WIDE BEACH 1300 FT LONG FRONTING SHEROD PARK. ANNUAL NOURISHMENT UNDER ALT 1 WILL RETARD EROSION FROM 14 FT/YR TO 1.0 FT PER YEAR. THIS IMPLIES THAT THE 20 FT WIDTH BEACH WILL RECEDE A FOOT PER YEAR AND BE TOTALLY LOST IN PROJ YEAR 20. TO DETERMINE AVERAGE ANNUAL RECREATIONAL BENEFITS FOR SHEROD BEACH UNDER ALT 1 FIRST IT MUST BE DETERMINED WHEN SUPPLY CAPACITY IS LESS THAN PROJECTED DEMAND

SHEROD BEACH (ADDITIONAL) ALT. 1

Pr Yr	PROJ PEAK DEMAND	ANNUAL PEAK CAPACITY	PROJ PEAK ATTEND.	PROJ NON PEAK DEMAND	ANNUAL NON PEAK CAPACITY	PROJ NON PEAK ATTEND.
0	1996	18027	1996	665	36053	665
10	2472	9013	2472	824	18027	824
11	2531	8112	2531	844	16224	844
12	2590	7211	2590	863	14421	863
13	2649	6309	2649	883	12619	883
14	2708	5408	2708	903	10816	903
15	2767	4507	2767	923	9013	923
16	2826	3605	2826	942	7211	942
17	2885	2704	2704	962	5408	962
18	2944	1803	1803	982	3605	982
19	3003	901	901	1001	1803	1001
20	3062	0	0	1021	0	0

AVE. ANNUAL PEAK-DAY BENEFIT: SHEROD BEACH (ADDITIONAL) ALT 1

$$(1996)(\$1.75)(9.3689)^{1)}(.07361)^{2)} + (2826-1996)(1.75)(.4416)^{3)}(9.3689)^{1)}(.07361)^{2)} + 2704(1.75)\times(.3104)^{4)}(.07361)^{2)} + 1803(1.75)(.2897)^{5)}(.07361)^{2)} + 901(\$1.75)(.2704)^{6)}(.07361)^{2)} =$$

AVE ANNUAL PEAK BEN = $13,058

1) P.W. OF 1 PER PERIOD FOR 16 PERIODS, 7 1/8%
2) CAPITAL RECOVERY FCT, 50 YRS @ 7 1/8%
3) AVE ANNUAL EQUIV. FCT 16 YRS OF STRAIGHT LINE GROWTH/16 YR PROJ LIFE.
4) P.W. OF 1, 17 YRS IN FUTURE @ 7 1/8%
5) P.W. OF 1, 18 YRS IN FUTURE @ 7 1/8%
6) P.W. OF 1, 19 YRS IN FUTURE @ 7 1/8%

Subject: VERMILION HBR SEC 111 (TETRA TECH JULY 80)
Computation of: RECREATIONAL VALUE ADDED UNDER MITIGATION ACT.
Computed by: JON BROWN Checked by: [illegible] 1022 81 Date: 21 OCT 81

XIII. 1) CONTINUED

AVE ANNUAL NON PEAK BENEFIT : SHEROD BEACH (ADDITIONAL) ALT 1

$(665)(\$1.75)(10.2394)^{1)}(.07361)^{2)} + (1001-665)(\$.75)(4.206)^{3)}(10.2394)^{1)}(.07361)^{2)} = \$1,064$

TOTAL AVE ANNUAL BENEFIT TO SHEROD BEACH (ADDITIONAL) FOR ALT 1

$3058 + $1,064 = $4,122

TOTAL RECREATIONAL VALUE ADDED UNDER ALT 1

$ 1547	(CITY BEACH ADDITIONAL)
4122	(SHEROD BEACH ADDITIONAL)
$ 5669	TOTAL

2) ALT 2 + 3 HAVE IDENTICAL RECREATIONAL VALUE ADDED BENEFITS BECAUSE BOTH ALTERNATIVES PROVIDE STABLE RESTORED BEACHES AT SHEROD AND CITY BEACHES (SEE WORKSHEET 3 of 16 OF THIS ANALYSIS) AND THEREFORE WOULD PROVIDE THE TOTAL AVERAGE ANNUAL BENEFITS CALCULATED ON WORKSHEET 13 OF 16.

TOTAL RECREATION VALUE ADDED UNDER ALT 2 AND 3

$ 1547	(CITY BEACH ADDITIONAL)
$ 6431	(SHEROD BEACH ADDITIONAL)
$ 7,978	TOTAL

3) ALT 4 (REVETMENT FROM PROPOSED MARINE MUSEUM GROIN TO COEN ROAD)

ONLY RECREATIONAL VALUE ADDED IS FROM RESTORED CITY BEACH (20 FT WIDE BEACH AT SHEROD PARK NOT BUILT) THEREFORE RECREATIONAL VALUE ADDED UNDER ALT 4 IS $ 1547

1) P.W. OF 1 PER PERIOD FOR 19 PERIODS
2) CAPITAL RECOVERY FACTOR 7 1/8 %, 50 YEARS
3) AVE ANNUAL EQUIVALENT FACTOR 19 YEARS STRAIGHT GROWTH, 19 YEAR PROJ LIFE @ 7 1/8 %.

Subject VERMILION HBR SECTION 111 (TETRA TECH, JULY 80)
Computation of SUMMARY OF DAMAGES AND BENEFITS (7 1/8%), 1980 P.L., BASE YR: 1980
Computed by JON BROWN Checked by pal 10/22/81 Date 14 OCT 81

AVERAGE ANNUAL DAMAGES

CONDITION	STRUCTURES $	LAND LOSS RESIDENTIAL $	LAND LOSS PUBLIC $	RECREATION $	TOTAL $
EXISTING CONDITIONS	8,076	9,428	4,253	$1,009	22,767
ALTERNATIVE 1	2,980	1,534	692	0	5,206
ALTERNATIVE 2	0	0	0	0	0
ALTERNATIVE 3	0	0	0	0	0
ALTERNATIVE 4	0	0	0	0	0

AVERAGE ANNUAL BENEFITS

	STRUCTURES $	LAND LOSS RESIDENTIAL $	LAND LOSS PUBLIC $	RECREATION EXISTING $	RECREATION VALUE ADDED $	TOTAL $
ALTERNATIVE 1	5,096	7,894	3,661	1,009	5,669	23,329
ALTERNATIVE 2	8,076	9428	4253	1,009	7,978	30,744
ALTERNATIVE 3	8076	9428	4253	1,009	7,978	30,744
ALTERNATIVE 4	8,076	9,428	4253	1,009	1,547	24,313

	TOTAL A.A. BENEFITS	TOTAL A.A. COSTS [1]	TOTAL NET BEN.	B/C
ALTERNATIVE 1	$23,329	$45,630	-22,301	.51
ALTERNATIVE 2	30,744	98,200	-67,456	.31
ALTERNATIVE 3	30,744	85,220	-54,476	.36
ALTERNATIVE 4	24,313	498,000	-473,687	.05

[1] SEE PAGE F-20.

Subject: VERMILION SEC 111 WEST SIDE

Computation of: FEDERAL NAV. STRUCTURE INDUCED DAMAGES VS. NATURAL DAMAGES

Computed by: JON BROWN Checked by: ______ Date: 5 NOV 81

THE PURPOSE OF THIS ANALYSIS IS TO PROVIDE THE SPLIT OF ANNUAL DAMAGES UNDER EXISTING CONDITIONS THAT ARE INDUCED BY THE FEDERAL NAVIGATION STRUCTURES WITH DAMAGES THAT ARE OCCURRING FROM NATURAL SHORE EROSION PROCESSES.

CATEGORY	TOTAL ANNUAL DAMAGES	FEDERALLY INDUCED	NATURALLY INDUCED	% FED	% NATURAL
STRUCTURE DAMAGES	$8076	$1,729	$6347	21%	79%
RESIDENTIAL LAND LOSS	$9428	$2694	$6,734	29%	71%
PUBLIC LAND LOSS	$4253	$1215	$3038	29%	71%
RECREATION BEACH LOSS	$1,009	$113	$896*	11%	89%
TOTAL	$22,766	$5,751	$17015	25%	75%

* REFER TO WORKSHEET 7 OF 16 DATED 14 OCT 81 *

COMPUTATION OF RECREATION LOSS UNDER NATURAL EROSION RATE (1.0 FT/YR) CONDITIONS

$60 \text{ SQFT/YR} \left(\frac{1.0 \text{ FT/yr}}{1.4 \text{ FT/yr}}\right) = 43 \text{ SQFT/YR} \times 50 \text{ YRS} = 2150 \text{ SQ FT}$

ANNUAL RECREATIONAL VALUE WITH NATURAL ANNUAL AREA LOSS OF 43 SQFT/YR OR 2,150 SQFT IN 50 YRS

PEAK (Pr Yr 50): $(4400 - 2150) \div 75 \times 2.0 \times 26 \times \$1.50 = \$2340$

NON PEAK (Pr Yr 50): $(4400 - 2150) \div 75 \times 2.0 \times 52 \times 1/3 \times \$1.50 = \$1560$

TOTAL (Pr Yr 50) $3,900

ANNUAL RECREATIONAL VALUE IN PROJ YEAR 0: $7627

ANNUAL RECREATIONAL VALUE IN PROJ YEAR 50: $3900

CHANGE IN VALUE OVER 50 YRS: $3727

CALCULATE P.W. OF NEGATIVE GROWTH (7 1/8%)

$$\$3727 + \frac{\$3727}{50}\left[\frac{50-1}{.07125} - \frac{1 - 1/(1.07125)^{49}}{.07125^2}\right] = 3727 + \frac{3727}{50}[497.493]$$

P.W. OF NEG GROWTH = $40,810; AVE. ANNUAL VALUE OF NEG GROWTH $40,810 · .07361 = $3,004

TOTAL AVE ANNUAL VALUE $3,004 + 3,727 = $6,731

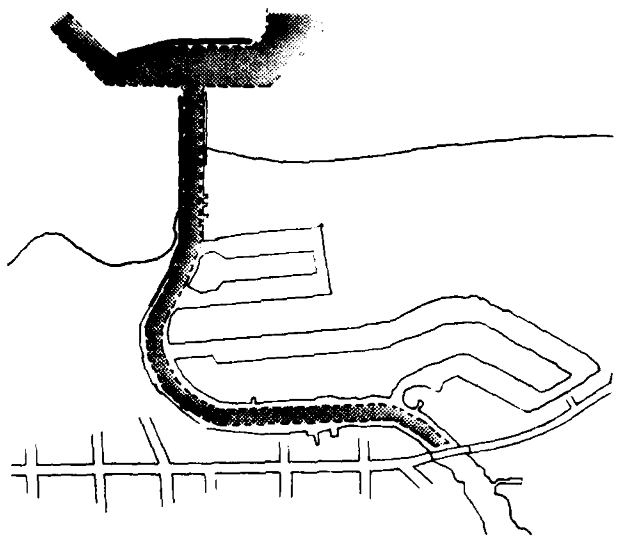
AVERAGE ANNUAL DAMAGES TO RECREATION BEACH UNDER NATURAL EROSION IS $7627 − $6731 = $896.

VERMILION HARBOR, OHIO

DETAILED PROJECT REPORT ON SECTION 111

SHORE EROSION STUDY

STAGE 3 DOCUMENTATION



APPENDIX C

OTHER PERTINENT STUDIES

U.S. ARMY CORPS OF ENGINEERS
BUFFALO DISTRICT
1776 NIAGARA STREET
BUFFALO, NEW YORK 14207

September 1982

EXHIBIT C.1

STALEY 1978 REPORT

VERMILION HARBOR, OHIO
SECTION 111 STUDY

STUDY OF THE
IMPACT OF THE FEDERAL NAVIGATION STRUCTURES ON SHORELINE PROCESSES

DRAFT REPORT

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS, BUFFALO DISTRICT
1776 NIAGARA ST.
BUFFALO, N.Y. 14207
MAY 1978

STUDY AND REPORT BY:

STANLEY CONSULTANTS
INTERNATIONAL CONSULTANTS IN ENGINEERING ARCHITECTURE PLANNING AND MANAGEMENT

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SECTION I - GENERAL

Introduction and Purpose

This report summarizes the results of an investigation of the shoreline changes of Vermilion, Ohio. The study area includes the coastal and related offshore areas in the vicinity of the federally constructed harbor facilities at Vermilion, as shown on Figure 1. Recent years and long past years have brought about significant changes in the shoreline alignment and distribution of beaches to the east and west of the Vermilion Harbor channel. The specific objective of this investigation was to determine the extent of shore damage, if any, due to navigation works and that due to natural processes, and to recommend whether consideration of mitigation measures is warranted.

Vermilion Harbor is a small craft harbor, located about 37 miles west of Cleveland. Deep-draft harbors at Huron and Lorain are about 11 miles west and east, respectively. The major harbor elements, shown on Figure 1, include east and west approach channels leading from the lake, the lower 3,600 feet of the Vermilion River, and four artificial lagoons. Channel protection is provided by parallel piers and an 864-foot detached offshore breakwater. The facilities are heavily used by recreational and commercial fishing craft, as evidenced by the 100,000 yearly trips to and from twelve yacht clubs and marinas.

Acknowledgements and Companion Report

This Section 111 study and report was prepared by Stanley Consultants of Muscatine, Iowa, for the U.S. Army District, Buffalo. The report is a companion to another Stanley report entitled "Vermilion Harbor Breakwater Impact Study, Impact of the Offshore Breakwater on Hydraulic and Environmental Conditions," dated March 1978, also prepared for the Buffalo District. A brief summary of the conclusions

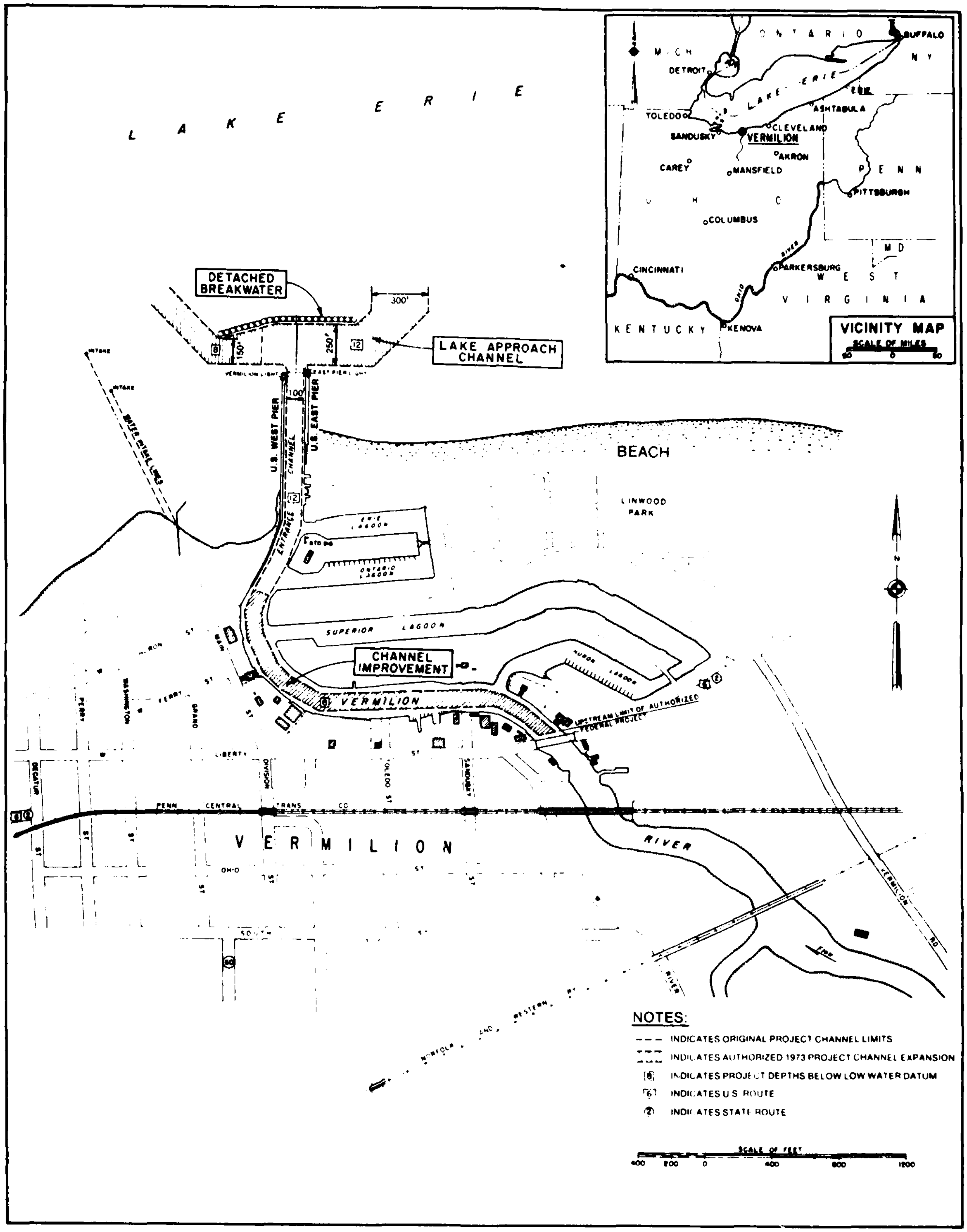


Figure 1 • VERMILION HARBOR LAYOUT & LOCATION

from that study is included in Section V of this report. For Stanley Consultants, Mr. William Allen was responsible for the technical investigations and report preparation under the direction of Mr. Bayard F. Weizenecker. Mr. John Annony served as Project Manager for the Corps during the report preparation, Colonel Daniel D. Ludwig was Buffalo District Engineer, and Donald M. Liddell was Chief of Engineering Division.

Study Authorization

This report was prepared under the authority of Section 111 of the River and Harbor Act of 1968, PL 90-483, approved August 13, 1968, which states:

> "The Secretary of the Army, acting through the Chief of Engineers is authorized to investigate, study and construct projects for the prevention or mitigation of shore damages attributable to Federal navigation works. The cost of installing, operation and maintenance shall be borne entirely by the United States. No such projects shall be constructed without specific authorization by Congress if the estimated first cost exceeds $1,000,000."

The investigation was requested by the state of Ohio Department of Natural Resources, William B. Nye, former Director, in a letter dated 13 December 1974.(1)

Development of the Vermilion Harbor Project

The natural state of the Vermilion River had sufficient depth to accommodate small craft only in the lower one mile reach prior to 1836. Depths reached 6 to 10 feet (Low Water Datum, Elevation 568.6 - IGLD-1955) for about 3,000 feet above the mouth, but less than two feet of water flowed over a sandbar at the mouth.(1)

The first harbor improvements were authorized by the 1836 Rivers and Harbor Act. Parallel piers were constructed 125 feet apart, extending lakeward to the 10-foot depth contour. The entrance channel was dredged to a depth of 8 feet. This work was completed in 1839. In 1874, the piers were extended to the 12-foot depth contour. No further lakeward extensions of the piers have been constructed. Repairs to

(1) Denotes reference presented at the end of the main report.

the piers have been made on several occasions. The height of the piers is now 6 to 6 1/2 feet above low water datum. The harbor channel was dredged to 12 feet between 1875 and 1878. The outer harbor remained essentially unchanged until 1973. Four lagoons on the Vermilion River were dredged in 1935 by Lewis Realty Company, and they are not part of the Federal Harbor.

The latest harbor improvements were authorized in 1958, in order to provide safer entrance conditions during heavy seas, and to reduce harbor surge. After consideration of several designs, a detached "T" type offshore breakwater was constructed approximately 300 feet lakeward of the east pier end (see Figure 1). East and west lake approach channels were dredged to 12 feet, and the 8-foot river channel was extended to 3,600 feet upstream of the pier ends. The breakwater construction and dredging were completed by December, 1973.

Prior Reports

A cooperative beach erosion control study of the entire Lake Erie shoreline of Ohio was made between 1947 and 1953.(2)(3) These reports provided a general description of the shoreline transport, but no detailed information regarding Vermilion. In 1964, the Ohio Department of Natural Resources published a report entitled "Effects of large structures on the Ohio Shore of Lake Erie."(4) Again the information is qualitative in nature. The Buffalo District prepared a preliminary Section 111 report in January, 1976,(1) upon which the present study is based.

In May, 1978, a Section 14 Reconnaissance Report(6) was prepared by Dalton, Dalton, Little, Newport, Inc., for the Buffalo District relating to the design of a protective revetment for the Linwood Park bluff at Vermilion, Ohio. This report provides some quantitative estimates of bluff erosion rates at Linwood Park for the period July 1975 to November 1976.

Study Work Elements

This study involved the following basic work items:

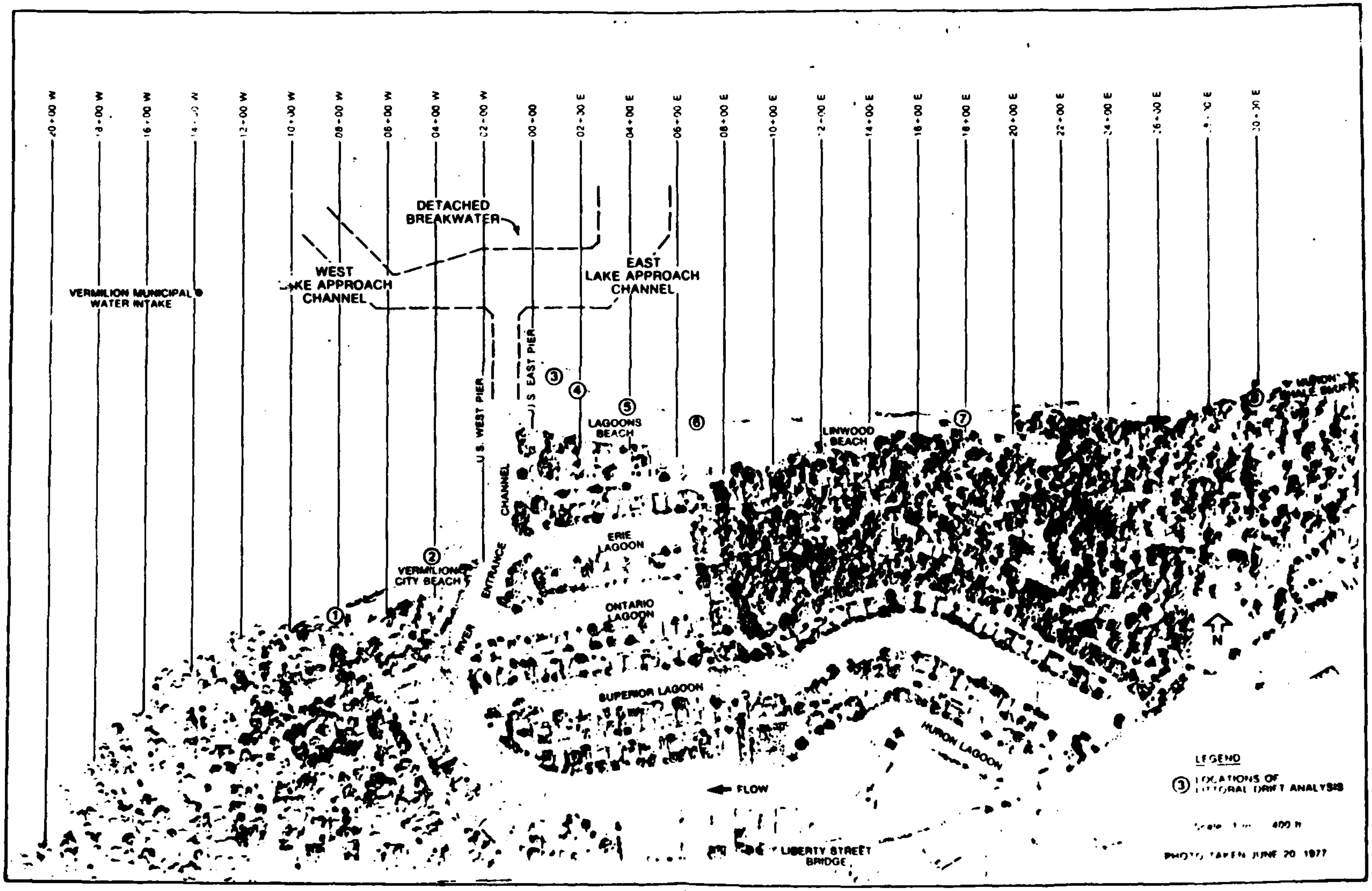


Figure 2 • MAJOR PROJECT ELEMENTS

1. An investigation of erosion rates and shoreline redistribution through the use of aerial photographs, and survey information.
2. A detailed presentation and evaluation of the littoral processes governing the shoreline characteristics.
3. A determination of the influence of all federally constructed navigation structures.
4. A sediment budget analysis.
5. A quantitative evaluation of the shoreline realignment and beach distribution changes as related to Federal navigation structures.
6. A recommendation as to whether mitigation measures are to be further considered.

Analysis of erosion from photographs and surveys is presented in Section III, and the littoral processes are described in Section IV. The following section provides background information regarding the general factors involved in shore processes as they relate to the Vermilion situation.

The major areas of interest include the Vermilion City Beach, extending 500 to 600 feet west of the west pier, and Lagoons and Linwood Beaches extending approximately 4,000 feet to the east of the harbor channel (see Figure 2).

SECTION II - SHORE PROCESSES AT VERMILION HARBOR

Introduction

The behavior of a specific reach of shoreline is dependent upon the composition and slope of the shoreline, the environmental forces that erode and transport material, and the presence or lack of sources of replacement material. Man-made coastal works also often have a critical influence by interrupting, modifying, or trapping the flow of sediment.

The basic mechanism for erosion on the Great Lakes involves waves attacking the shoreline and wearing away the coast. Material is raised into suspension in the water and carried away by wave induced longshore or offshore currents. Some sediments are also moved along the bottom by wave forces (bed load). The transport of material in the nearshore region is called littoral drift. Net erosion occurs when more material is transported from a location than is brought to it, whereas net accretion results from a surplus of input sediment.

The amount of erosion and/or sediment transport occurring along a coastline depends upon the material quantity and composition and shore slope. Stable sand beaches often provide excellent protection from the erosive forces of lake waves. If no beach is present, erosion proceeds at varying rates depending upon the shore material, slope, and orientation. The most significant factors of the study area related to shoreline erosion and transport are briefly discussed below.

Shore and Beach Characteristics - West of Vermilion Harbor

The shoreline conditions described are the existing conditions in 1977. Immediately west of the west pier, an exposed sand beach (Vermilion City Beach) 50 to 75 feet wide extends 600 feet to the west. The bluff behind the beach is about 10 feet high and consists of boulder clay overlain with lacustrine deposits. To the west of City Beach the shoreline is almost completely developed with residences. Numerous short

groins or stone-filled timber cribs have been built to trap protective beaches, and have met with limited success. The height of the bluff gradually increases to the west, reaching 30 feet about 4 miles from Vermilion.

The nearshore lake bottom immediately west of the harbor is hard shale, with some cobbles and boulders and occasional small sand deposits (see Figure 4).

Photographs 1 through 3 show the shoreline west of Vermilion Harbor.

Shore and Beach Characteristics - East of Vermilion Harbor

The principal area of interest to this study is a 3,000-foot beach commencing at the east harbor pier. The beach is presently 250 feet wide at the pier, tapering to zero at the east end. The material is fine to medium sand, with gravel and cobbles prevalent near the water line. Development of this beach represents the last step in a pattern of accretion adjacent to the east pier which began after its construction in 1837. It has been estimated that at least 500 feet of accretion occurred from 1837 to 1847, which now is part of the Lagoons Subdivision.

The beach area ends at the base of a steep Huron formation shale bluff approximately 10 to 15 feet high. Glacial material 5 to 12 feet thick covers the bluff. The shale outcrop extends for about 2 1/2 miles to the east, where it dips below lake level, remaining submerged until it rises above water level about one mile east of Lorain. Grain size analysis of the bluff material indicates that only 12 percent of the material is fine sand or coarser and suitable for natural beach building.

The bluff behind Linwood Beach has a much larger percentage of sand, but is too short to be a significant beachbuilding source.

Where the shale surface is submerged, the coastline is primarily boulder clay overlain with sand deposits with a few small sand pockets. More complete discussions of the geology are given in References 2 and 3.

Photographs 4 through 7 show the sand beach and bluff to the east of Vermilion.

Offshore Conditions

Offshore bottom contours existing in 1967 and 1977 are shown in Figure 3. It can be seen that little change occurred during this 10-year


Photo 1 • VERMILION CITY BEACH (Aug., 1977)


Photo 2 • SHORELINE WEST OF VERMILION: SHOWING PROTECTIVE STRUCTURES AND SMALL BEACHES (April, 1977).

Photo 3 • WEST END OF CITY BEACH (Aug., 1977)

Photo 4 • LINWOOD AND LAGOONS BEACHES (Aug., 1977).

Photo 5 • EAST END OF LINWOOD BEACH TAPERING TO SHALE BLUFF (Aug., 1977).

Photo 6 • BLUFF EROSION AT LINWOOD BEACH (May, 1977)

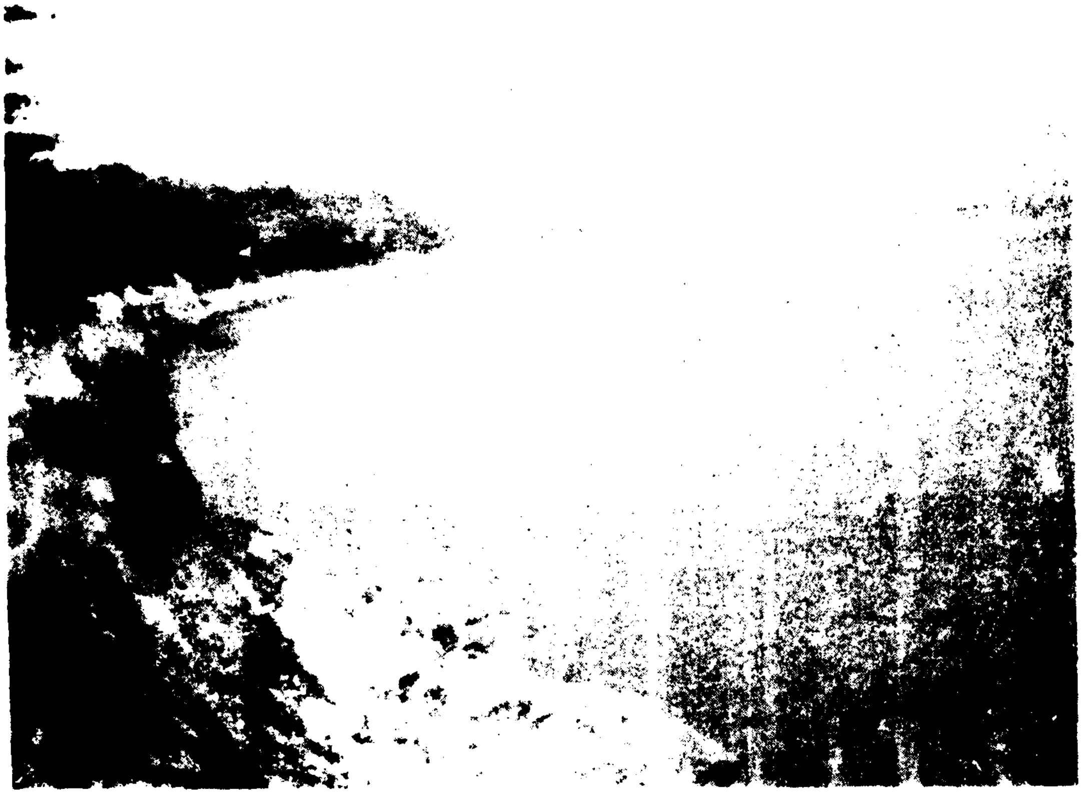


Photo 7 • BLUFF EAST OF LINWOOD BEACH (May, 1977).

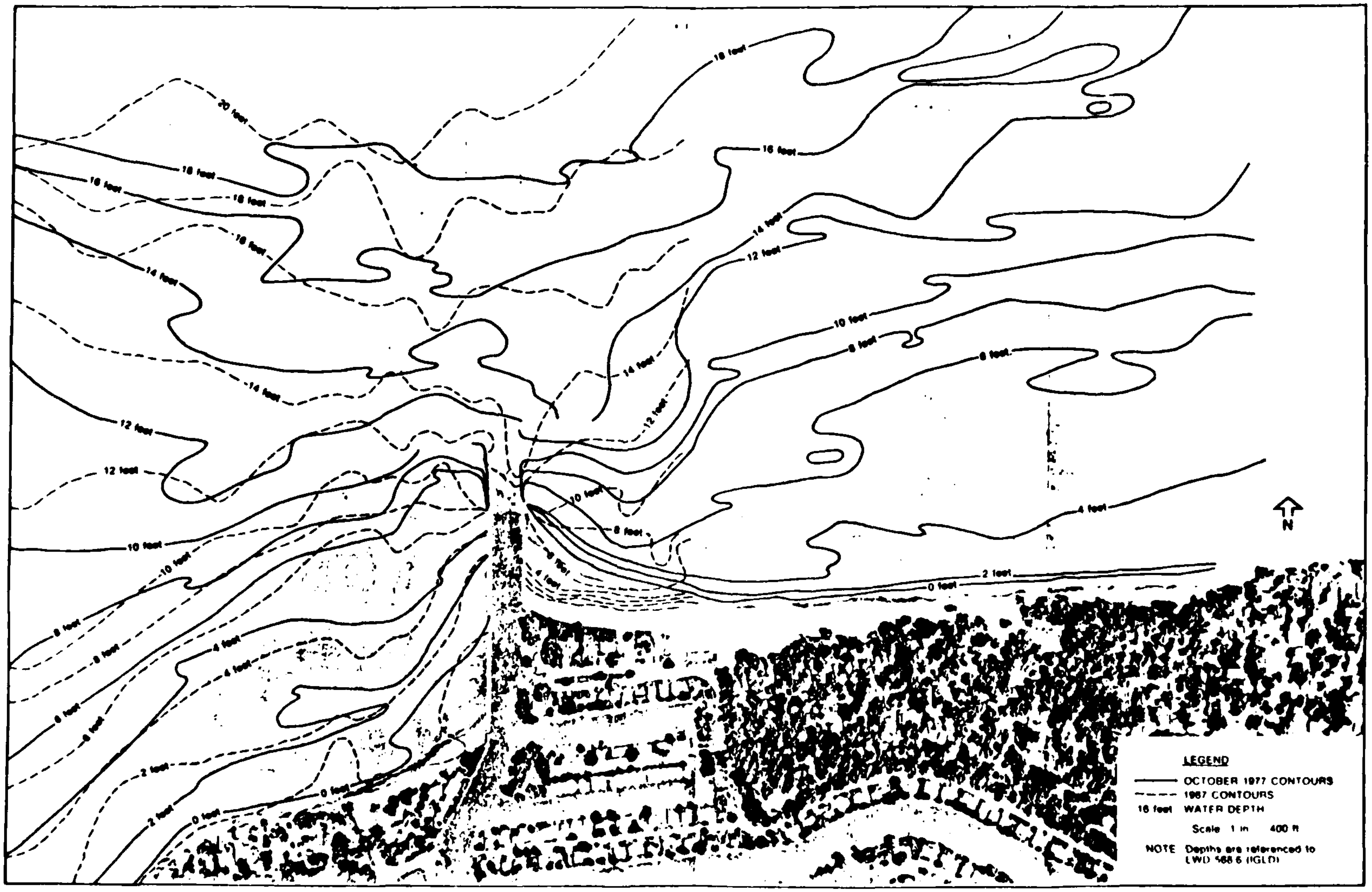


Figure 3 • OFFSHORE BOTTOM CONTOURS

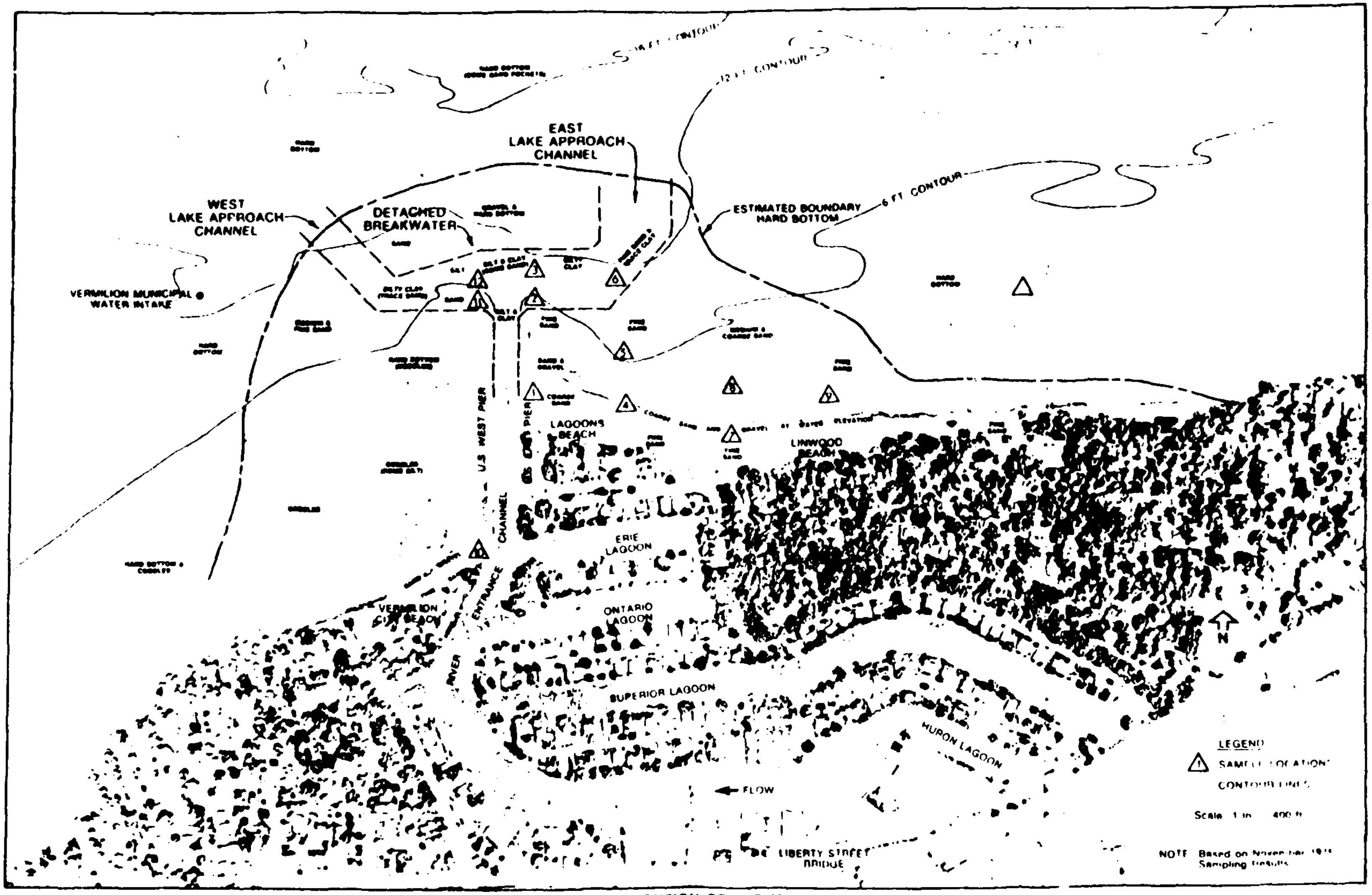


Figure 4 • DISTRIBUTION OF BED MATERIAL

6 f

period at depths greater than 4 feet between stations 22+00W and 8+00E (the limits of the 1967 survey), except in the lake approach channel.

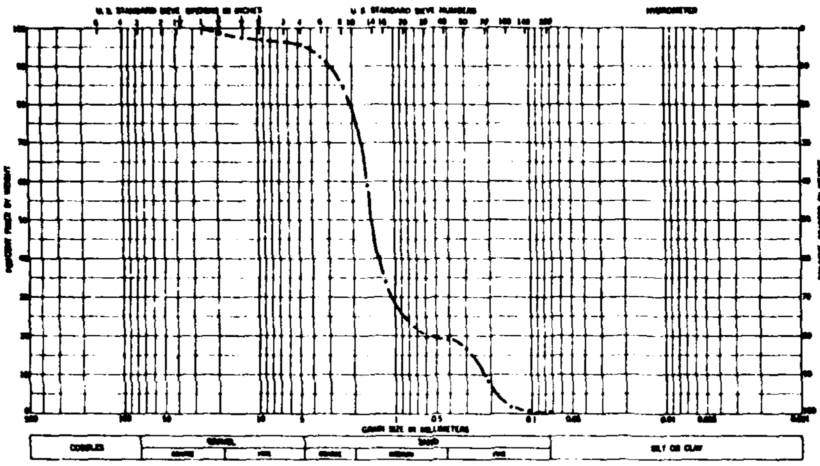
The nearshore bottom material generally consists of sand parallel and adjacent to the shoreline. Hard bottom with cobbles predominate offshore, as shown on Figure 4. Sediment samples of the beach and bed material were taken by the Corps of Engineers in November and December, 1976. Sediment grading curves are shown on Figures 5 through 8. Beach sediment is fine to medium sand, with gravel interspersed along the shoreline. Sediments in the lake approach channels are essentially clay and silt, with some fine sand near pier ends.

Natural Forces

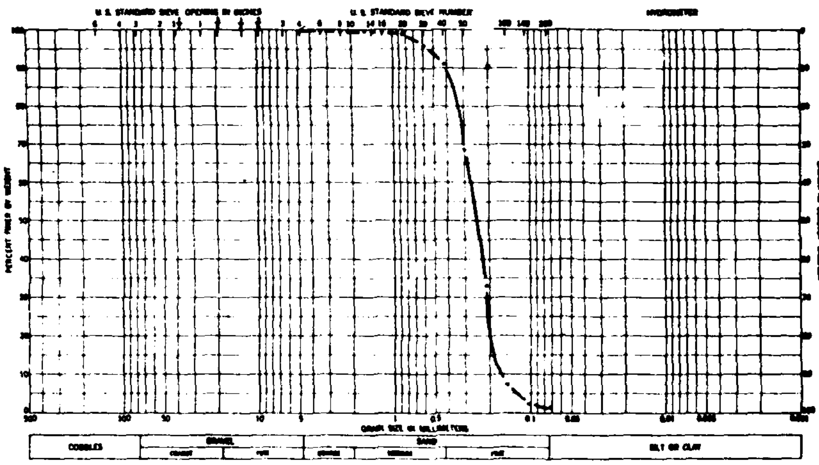
Waves - The dominant forces involved in shoreline erosion are winds and waves. Breaking waves impart energy upon the shoreline, resulting in erosion and transport of beach material. At Vermilion, the larger, steeper waves, created by strong northeast and northwest winds, are the most effective in eroding and moving sedimentary material. Smaller (less steep) waves tend to push sediment onshore and aid in building the Vermilion Beaches. It is the relative frequency of wave heights and directions that determine the net effect on a shoreline.

Winds - Winds act directly upon beaches by creating shear forces upon the individual sand particles and thereby blowing sand off the beach (deflation) or depositing sand in dunes. Winds move sand in three ways: 1) suspension where small particles are lifted and held in the air stream; 2) saltation where particles are carried in a series of short jumps; and 3) surface creep where particles roll or bounce along the beach. Most particles move by saltation. Sand moved seaward usually falls into the wave breaking zone and, although lost to the beach, still remains in the littoral transport zone.

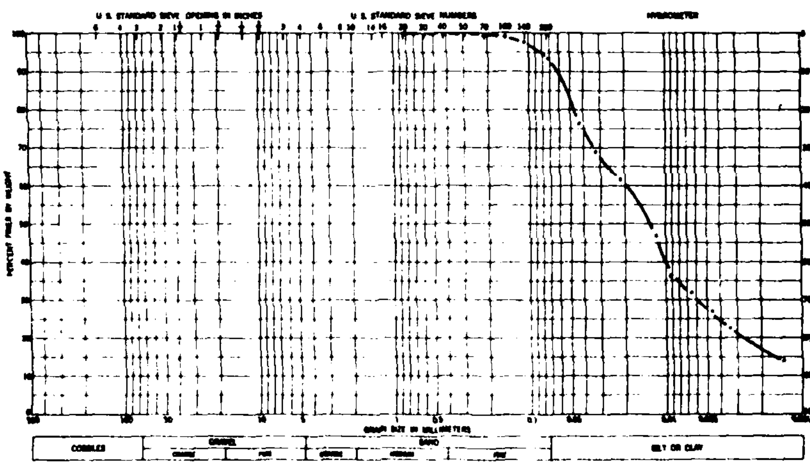
Average rates of deflation are highly variable. The largest wind transport losses are usually associated with accreting beaches that provide a broad area of loose sand. Such a circumstance could occur at Lagoons Beach where sand overtopping the east pier necessitated



SAMPLE NUMBER: 1
STATION POINT: 0+00 E
DATE: 12/8/76



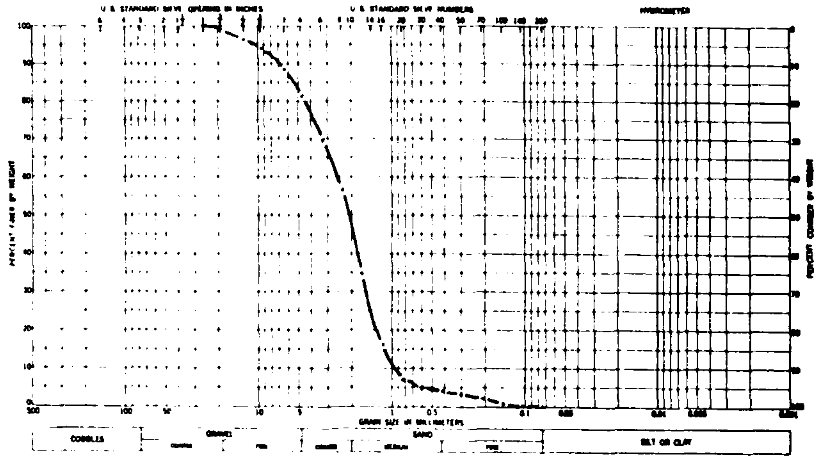
SAMPLE NUMBER: 2
STATION POINT: 0+00 E
DATE: 11/26/76



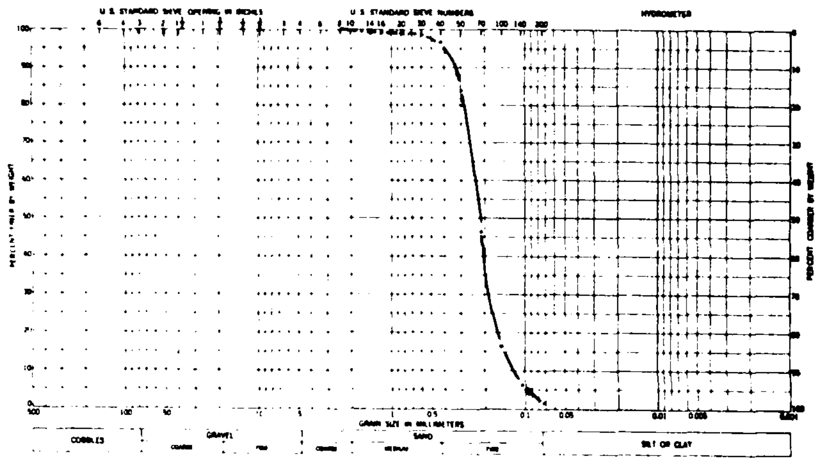
SAMPLE NUMBER: 3
STATION POINT: 0+00 E
DATE: 11/15/76

NOTE: Sample locations shown on Figure 4

Figure 5 • SEDIMENT GRADING CURVES - STATION 0+00 E



SAMPLE NUMBER: 4
STATION POINT: 4+00 E
DATE: 11/16/76



SAMPLE NUMBER: 5
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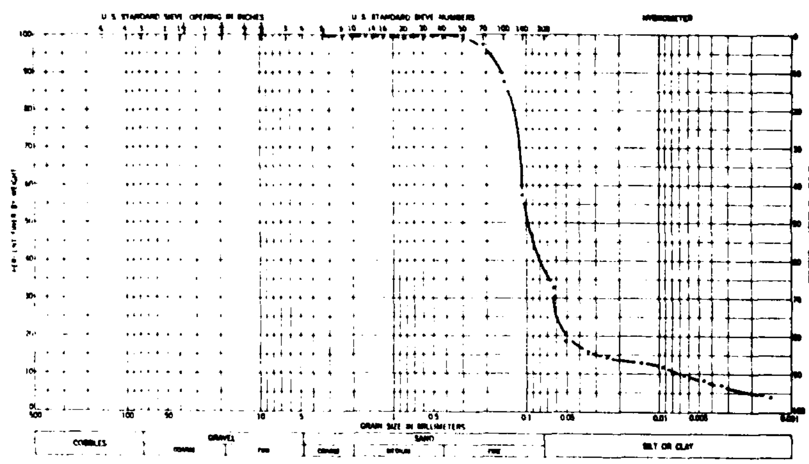
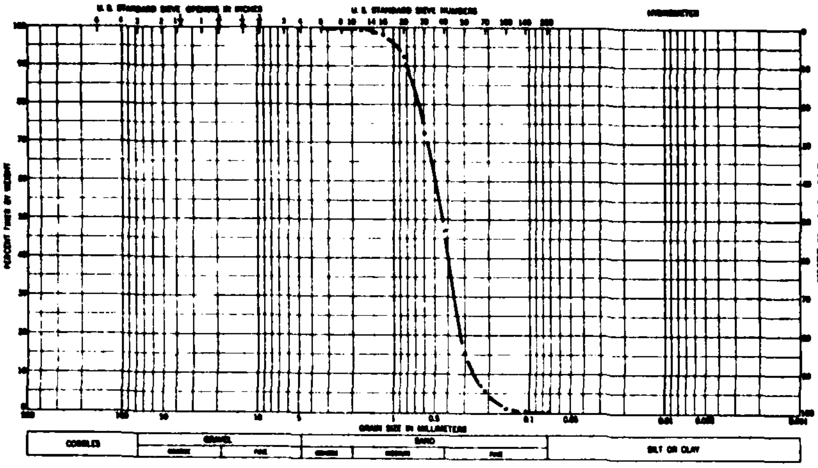
DATE: 11/19/76



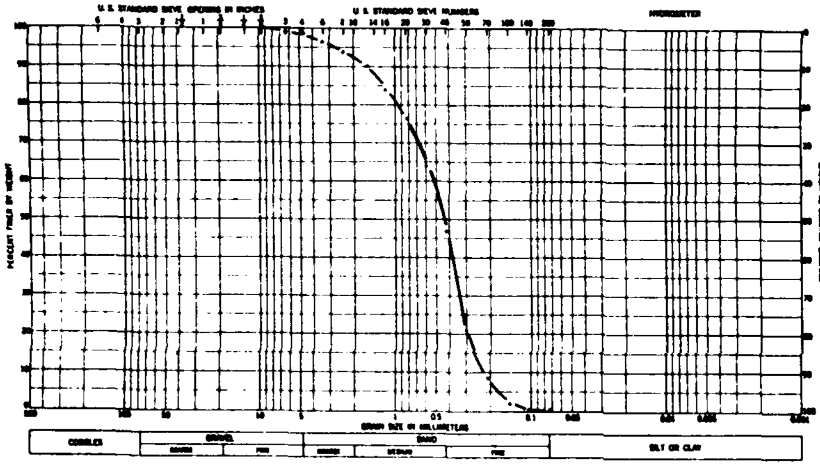
SAMPLE NUMBER: 6
STATION POINT: 4+00 E
DATE: 11/15/76

NOTE: Sample locations shown on Figure 4

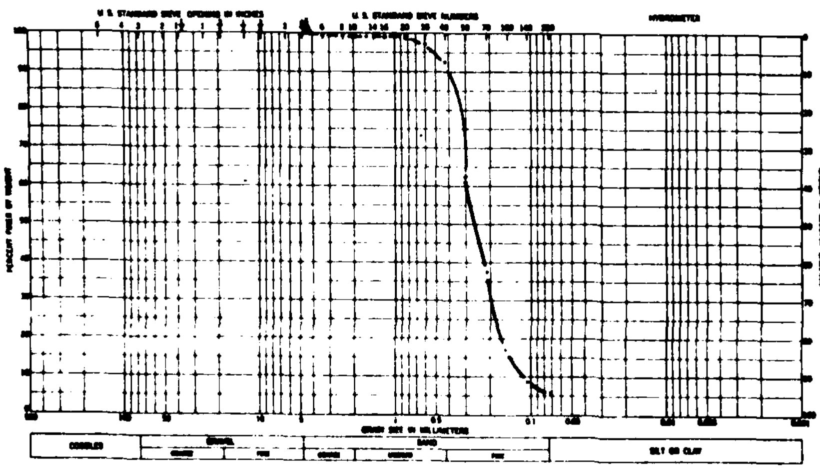
Figure 6 • SEDIMENT GRADING CURVES - STATION 4+00 E



SAMPLE NUMBER: 7
STATION POINT: 8+00 E
DATE: 11/11/76



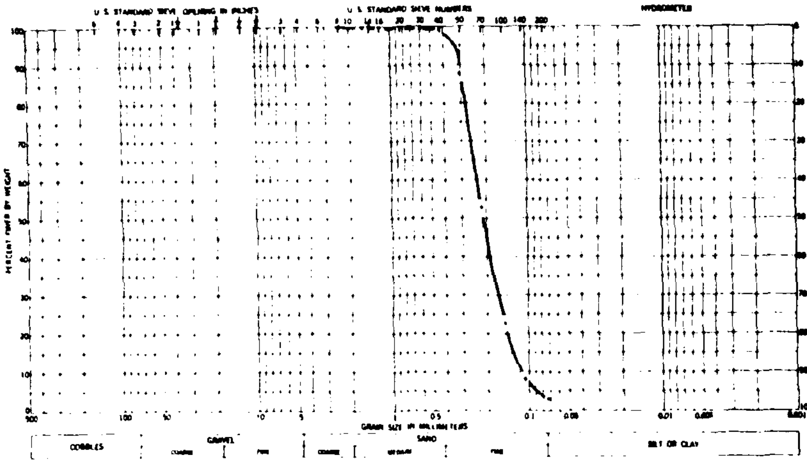
SAMPLE NUMBER: 8
STATION POINT: 8+00 E
DATE: 11/30/76



SAMPLE NUMBER: 9
STATION POINT: [illegible] 00 E
DATE: 11/26/76

NOTE: Sample locations shown on Figure 4

Figure 7 • SEDIMENT GRADING CURVES - STATION 8+00 E AND 12+00 E



SAMPLE NUMBER: 10
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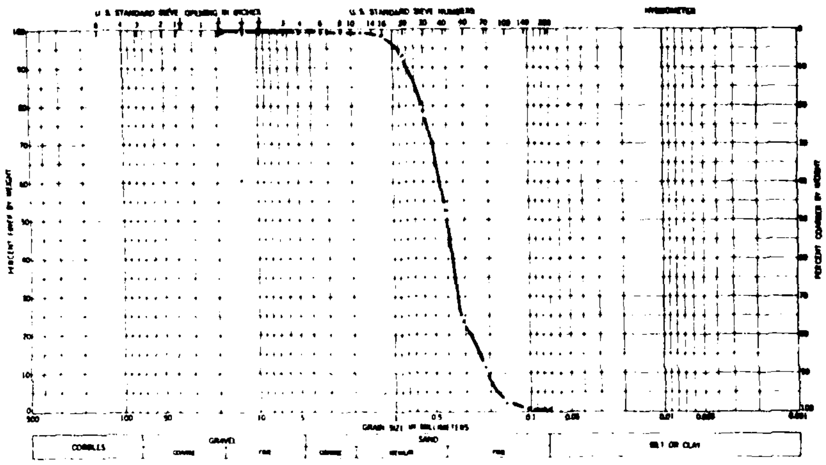
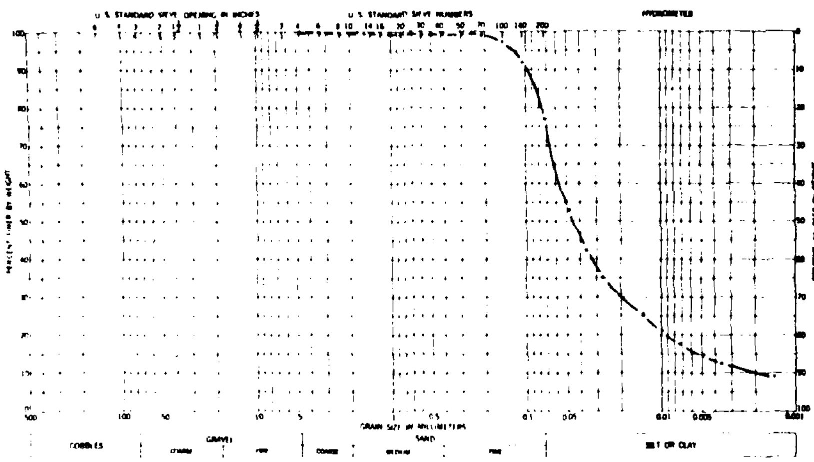
DATE: 11/23/76



SAMPLE NUMBER: 11
STATION POINT: 2+00 W
DATE: 11/10/76



SAMPLE NUMBER: 12
STATION POINT: 2+00 W
DATE: 11/18/76

NOTE: Sample locations shown on Figure 4

Figure 8 • SEDIMENT GRADING CURVES - STATION 2+00 W

entrance channel dredging of 8,550 cubic yards in December 1975. Except for this one spot, wind transport is not thought to be of significance at Vermilion.

Water Levels - Fluctuations in the lake level may cause an extensive alteration of shoreline conditions. As the water level rises, waves more frequently cross the previously stable beach, causing erosion of a shoreward bank. This process frequently results in undercutting of steep bluffs and sloughing. For a beach system, the effects of rise and fall in water level do not balance. High water levels permit erosion of the bluffs whereas during periods of low water level, these shoreline features are not replaced. Even a wide protective beach will readjust to higher water levels by erosion of the berm and accretion offshore. The changing lake level also upsets the previous shoreline balance by permitting larger waves to break closer to shore.

The beach material in the wave breaking zone is moved more readily than material offshore, which will only be subjected to oscillating, non-breaking wave forces. A beach face will therefore readjust quickly to a change in water level conditions, but offshore areas will adjust more slowly.

The orientation, or beach face azimuth, of the shoreline will not be significantly affected by variations in water level unless refraction of the waves is altered; that is, unless irregularities in bed topography occur through exposure or inundation of beach material. Such irregularities are not significant at Vermilion since the bed is formed by relatively parallel bottom contours. Hence, variation in lake level does not significantly alter the angle of waves breaking on the beaches at Vermilion, and little significant change in the net transport of sediment on the beaches is to be expected.

In the Vermilion area, stillwater water levels vary widely, as indicated in Table 1. These fluctuations are produced by rainfall and runoff in the Great Lakes basin, and are unpredictable except for within 4 to 6 months in advance. Seasonal cycles also produce variations of 1 to 2 feet with the highest annual elevations in June and July.

TABLE 1

LAKE ERIE LEVELS 1860-1974

Item	Elevation IGLD	Elevation LWD(1)	Date
Highest monthly mean stage	573.51	4.91	June 1973
Lowest monthly mean stage	567.49	-1.11	Feb. 1936
Long term mean surface (1860-1977)	570.36	+1.76	
Yearly Mean 1968	570.92	+2.32	
Yearly Mean 1969	571.54	+2.94	
Yearly Mean 1970	571.10	+2.50	
Yearly Mean 1971	571.27	+2.67	
Yearly Mean 1972	571.89	+3.29	
Yearly Mean 1973	572.71	+4.11	
Yearly Mean 1974	572.52	+3.92	
Yearly Mean 1975	572.27	+3.67	
Yearly Mean 1976	572.10	+3.50	
Yearly Mean 1977	571.24	+2.50	

(1) Feet above low-water datum, 568.6 (IGLD).

In addition to annual and seasonal fluctuations, storms produce water level changes due to barometric pressure changes or prolonged strong winds. Wind induced "set-up" results when strong winds drive the water, raising the leeward shore and lowering the windward shore. This effect can result in water level changes of 1.8 feet once a year and 2.3 feet once every five years at Vermilion.[1]

Ice - An ice cover along the shoreline can substantially reduce erosion by reducing the wave energy imparted to the shore. For this reason, the analysis of littoral drift is usually conducted only for ice-free periods.

Sources of Sediment

The process of erosion versus accretion of a beach is dependent upon a balance of the hydraulic factors discussed above and the supply of sediment to the littoral system. The only three possible sources of sediment for Vermilion area beaches are the Vermilion River, bluff erosion, or offshore deposits. Sediments carried by the Vermilion River are essentially silt and clay, thereby ruling out the river as a source of beach sand. Offshore deposits of any significant magnitude apparently do not exist in the nearshore areas off Vermilion. (See Figure 4.) Erosion of bluffs to the east therefore appears to be the only major sediment source for the Vermilion beaches. There are also some small pockets of sand along this shore which may be an additional small source, or temporary storage sites.

The amount of beach building sand generated by bluff erosion varies greatly primarily due to changing water level. The reach of coast that is significant for supplying sand to Linwood and Lagoons Beaches extends approximately five miles to the east. The piers at the harbor entrance serve as a barrier to littoral transport from west to east and hence sources of beach material from the west are negligible. Some of this area is already protected by natural or man-made barriers. It is estimated that approximately 50 to 60 percent of the area is actively eroding. Previous studies[(3)(5)] have indicated that the long-term recession rate of this shoreline stretch averages approximately one foot per year. With an average bluff height of 15 to 20 feet and 12 percent sand content, approximately 1,000 cubic yards per year of beach building material is added to the littoral system. It is emphasized that this is a long-term average from 1876 to 1948. In any given year, the erosion may be many times this rate. For example, surveys taken in July 1975, and November 1976, indicated a shoreline recession east of Linwood Park of 10 feet.[(6)] It is apparent that annual volume of beach building material eroded may easily exceed 10,000 cubic yards per year where high water levels occur. During 1971 to 1975 Lake Erie attained record water levels, and heavy erosion occurred at several spots along this reach.

The Section 14[6] study of Linwood Park Beach states that 400 feet of Linwood Park bluff had eroded 10 feet due to wave action between July 1975, and November 1976. This would result in approximately 1,000 cubic yards of material eroding during this period of which a high percentage could be expected to have beach building potential. This material is not considered as a significant source of sediment due to its relatively small volume in relation to the sediment budget. Historical evidence shows that a 10-foot per year recession rate has not occurred over a long period. This extreme recession rate is undoubtedly a result of the unusually high lake levels.

The erosion that has taken place on the Linwood Park bluffs can not be correlated with the beach erosion there. It is quite possible to have eroding bluffs and yet have a stable beach. Beach erosion is reversible when incident wave conditions change and restore the beach; bluff erosion is an irreversible process for the bluffs will not be replaced.

The stability of any area is determined by the balance of sediment input and outflow. The ability of source material to reach the Vermilion area is a critical factor in maintaining a stable beach.

Environmental Considerations

A brief description of the environmental setting provides an orientation to it and facilitates understanding the environmental impacts of shoreline erosion. The bulk of the information is taken from the final EIS for operation and maintenance, Vermilion Harbor, 1976. The 4,000-foot segment of Lake Erie shoreline extending east from the east pier consists of about 3,000 feet of sand beach and 1,000 feet of rock bluff. The beach is almost 300 feet wide adjacent to the east pier of the Vermilion River tapering to zero where the rock bluff begins. The bluff gradually rises to about 40 feet above the lake. Huron Formation shales of the upper Devonian Period are blue-gray to black in outcroppings along the bluff and are exposed on the lake bottom.

Terrestrial vegetation of the residential areas adjacent to the shoreline consists of trees, shrubs, weeds, and grasses. This vegetation serves

as wildlife habitat, ground cover, food for animals, and increases the aesthetic value of the area. The dominant, mature deciduous species are red maple, sugar maple, cottonwood, ash, hickory, red oak, and white oak. Oaks and hickories are important tree species because they provide food, shelter, and den sites for mammals and birds in the harbor area.

Terrestrial wildlife contributes to the aesthetic, ecological, and recreational aspects of the area. The relatively poor habitat for mammals supports only those species which are tolerant of man. Typical species are the house mouse, norway rat, oppossum, raccoon, eastern cottontail, and fox squirrel. Bird species include the starling, house sparrow, rock dove, nighthawk, and chimney swift as well as the water-associated birds such as gulls, terns, sandpipers, plovers, and rails. Waterfowl using the Mississippi flyway migrate through the Vermilion area. These birds generally use open water except during storms when they enter the harbor. Mallards are year-round residents and utilize the harbor freely. Five rare and endangered birds are listed by the State of Ohio as occurring in the general area. No rare or endangered herptiles are found in the project area.

Living organisms in the aquatic environment are vegetation, plankton, benthos, and fish. The species diversities, communities, and populations of these organisms are good indicators of water quality. Studies performed in the Vermilion River area indicate slightly to moderately polluted water. More specifically, these studies show 1) a trend toward decreasing phytoplankton concentrations, 2) pollution tolerant benthos, 3) a dominance of less desirable, pollution tolerant fish species. Ten species of fish listed as endangered by the State of Ohio may be present in the estuary portion of the Vermilion River.

Land use along the shoreline is primarily residential development. Residences consist of seasonal cottages, year-round single family residences and multi-family residences. Older homes and cottages along the beach are well kept and many of the residences along the bluff portion of the shoreline have been constructed relatively recently.

Recreational uses made of the beach and adjacent water areas include recreational boating, fishing, swimming, scuba diving, sunbathing, walking and sightseeing (photography).

SECTION III - ANALYSIS OF HISTORICAL SHORELINE CHANGES 1836-1978

Introduction

The objective of this historical analysis was to determine and quantify areas of accretion and erosion along the beaches adjacent to Vermilion Harbor and to estimate the magnitude and extent of any onshore-offshore transport that might exist. Of primary consideration was the distribution of sand before and after construction of the offshore breakwater (1973). However, an overall evaluation of shoreline changes from 1836 to the present has been conducted. The effects of factors such as harbor construction and high lake levels have been analyzed.

Methodology

For the purposes of this analysis, the shoreline encompassing Vermilion City Beach to the west and Lagoons, Linwood Park, Nakomis, and Crystal Shores Beaches to the east was examined. The east limit of the system was taken to be a line parallel and 4,000 feet to the east of the east pier, where Crystal Shores Beach terminates and the shoreline becomes steep shale bluffs. To the west, a line parallel and 1,000 feet to the west of the west pier was chosen as here Vermilion City Beach also gives way to rock.

Available historical data in the form of aerial photographs, offshore sounding charts, and shoreline surveys were obtained for this reach of shoreline. This data was used to reveal the historical trends of shoreline position. The primary period of interest was selected such that the effects of the breakwater constructed in 1973 could be examined. Hence, the time intervals of November, 1937 to April, 1968; April, 1968 to April, 1971; April 1971 to April, 1973; April, 1973

to August, 1974; and August, 1974 to May, 1978, were considered. It was also possible, to some extent, to determine the intersection of the shoreline with the piers, from sounding charts taken in the 1800's.

Table 2 presents a summary of the data used to evaluate shoreline changes. The analysis procedure is described below.

A reference line was established perpendicular to the north-south axis at the north end of the U.S. east pier of Vermilion Harbor. Station transects were established perpendicular to the reference line at 100 foot intervals for a distance of 2,200 feet west (to station 22+00W) and 4,000 feet east (to station 40+00E). A point 25 feet east of the east pier on the reference line was station 00+00. All distances and positions were referenced to this line.

In order to use aerial photographs for sand volume computations, several simplifying assumptions were necessary regarding beach slope, maximum height of berm, and probable seaward limit of significant transport. Beach profiles taken in 1967, 1975, 1976, 1977, and 1978 were analyzed, and are shown on Figures 9 through 13. It was determined that the beach slope remained essentially constant at each station, although minor variations between stations were evident. Therefore, a typical value of slope could be assigned for each station. Likewise, berm heights remained fairly constant, and a representative value was determined for each station. Comparison of offshore soundings over the 10-year period revealed that, except in the Lagoons Beach area to the east of the channel, significant changes did not occur at depths greater than 4 feet (see Figure 3 and beach profiles). The bottom is hard material. It was concluded that onshore-offshore transport is not important past this depth. Volume calculations were therefore limited to this depth. From station 00+00E to 8+00E, calculations were carried into deeper water. The estimated values for berm height, slope, and offshore limit of transport are shown with the results in Table 3.

TABLE 2

SUMMARY OF HISTORICAL DATA

Date	Type of Data	Water Level (1)(2)	Range (ft)	Source
September 30, 1854	Soundings	N.A.	Harbor Entrance Only	U.S. Army Corps of Engineers or
October, 1875	Soundings	570.4		U.S. Army Corps of Engineers
November, 1879	Soundings	569.2		U.S. Army Corps of Engineers
October 31, 1937	Aerial Photograph	569.1	1,000 W-4,000 E	
April 20, 1949	Aerial Photograph	570.6	1,000 W-3,000 E	Ohio Dept. of Transportation
November, 1967	Soundings-beach profiles	570.2	1,000 W-700 E	U.S. Army Corps of Engineers
April 2, 1968	Aerial Photograph	570.9	1,000 W-4,000 E	Ohio Dept. of Transportation
April, 1971	Aerial Photograph	571.5	1,000 W-4,000 E	U.S. Dept. of Agriculture
April 20, 1973	Aerial Photograph	573.3	1,000 W-4,000 E	U.S. Dept. of Transportation
July 1, 1974	Aerial Photograph	570.0	1,000 W-4,000 E	Ohio Dept. of Transportation
November 18, 1975	Soundings-beach profiles	571.7	o E-4,000 E	U.S. Army Corps of Engineers
August, 1976	Soundings-beach profiles	572.6	1,000 W-3,200 E	U.S. Army Corps of Engineers
October 25, 1977	Soundings-beach profiles	571.0	1,000 W-2,800 E	U.S. Army Corps of Engineers
May 10, 1978	Soundings-beach profiles	572.1	1,000 W-2,800 E	U.S. Army Corps of Engineers

(1) Low Water Datum = 568.6 feet IGLD–1955.

(2) Monthly average at Cleveland, Ohio.

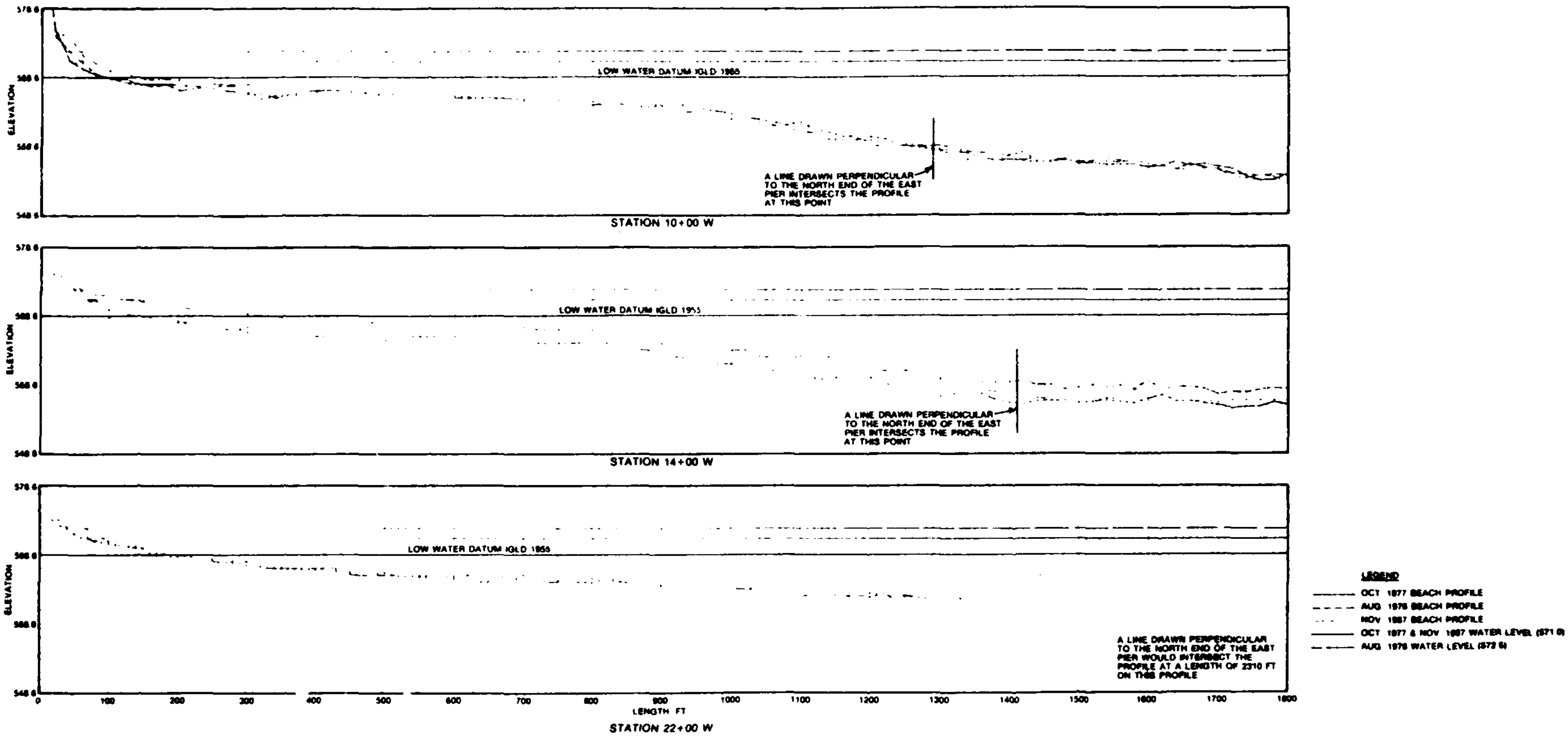


Figure 9 - BEACH PROFILES - STATIONS 10+00 W, 14+00 W, 22+00 W

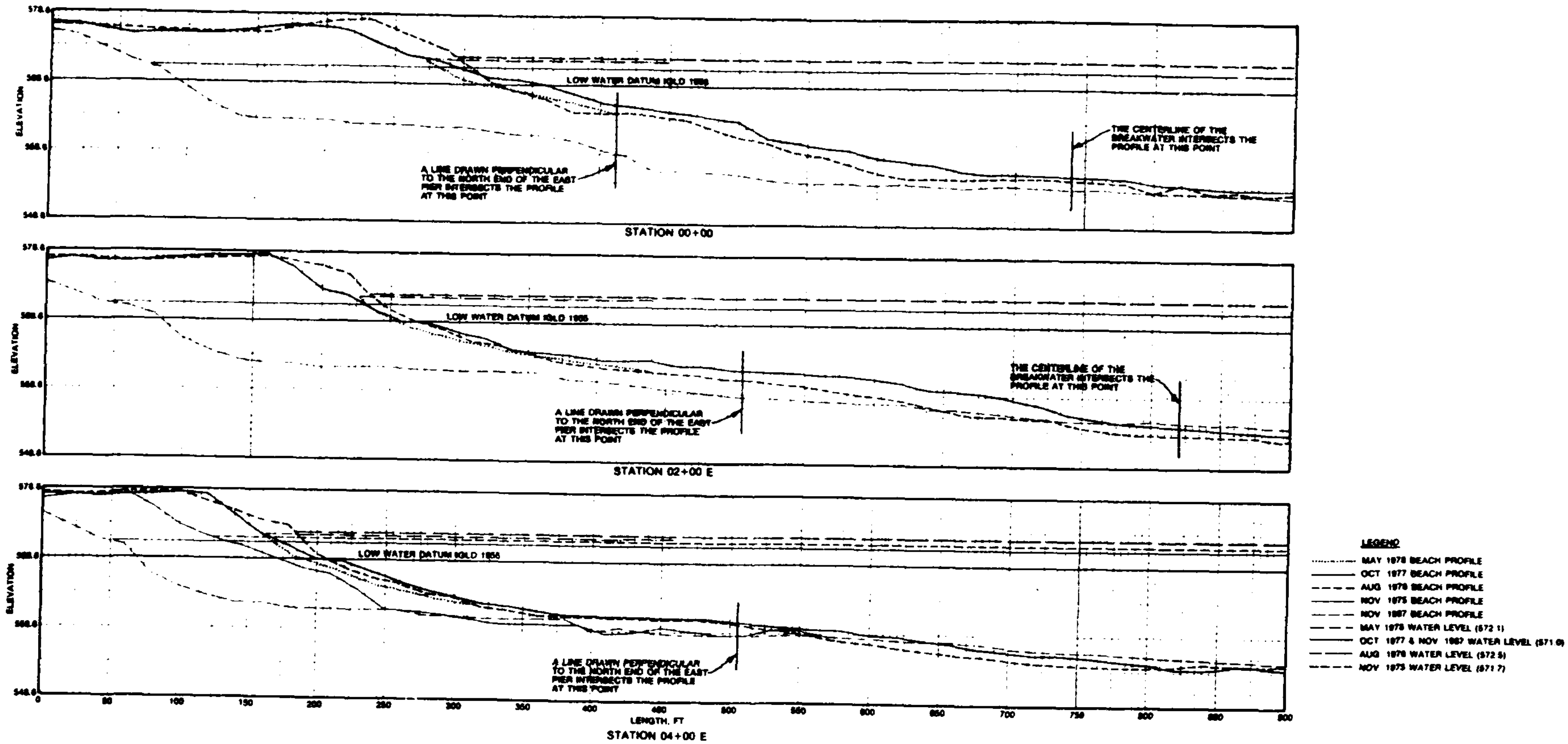


Figure 11 • BEACH PROFILES - STATIONS 0+00 E, 2+00 E, 4+00 E

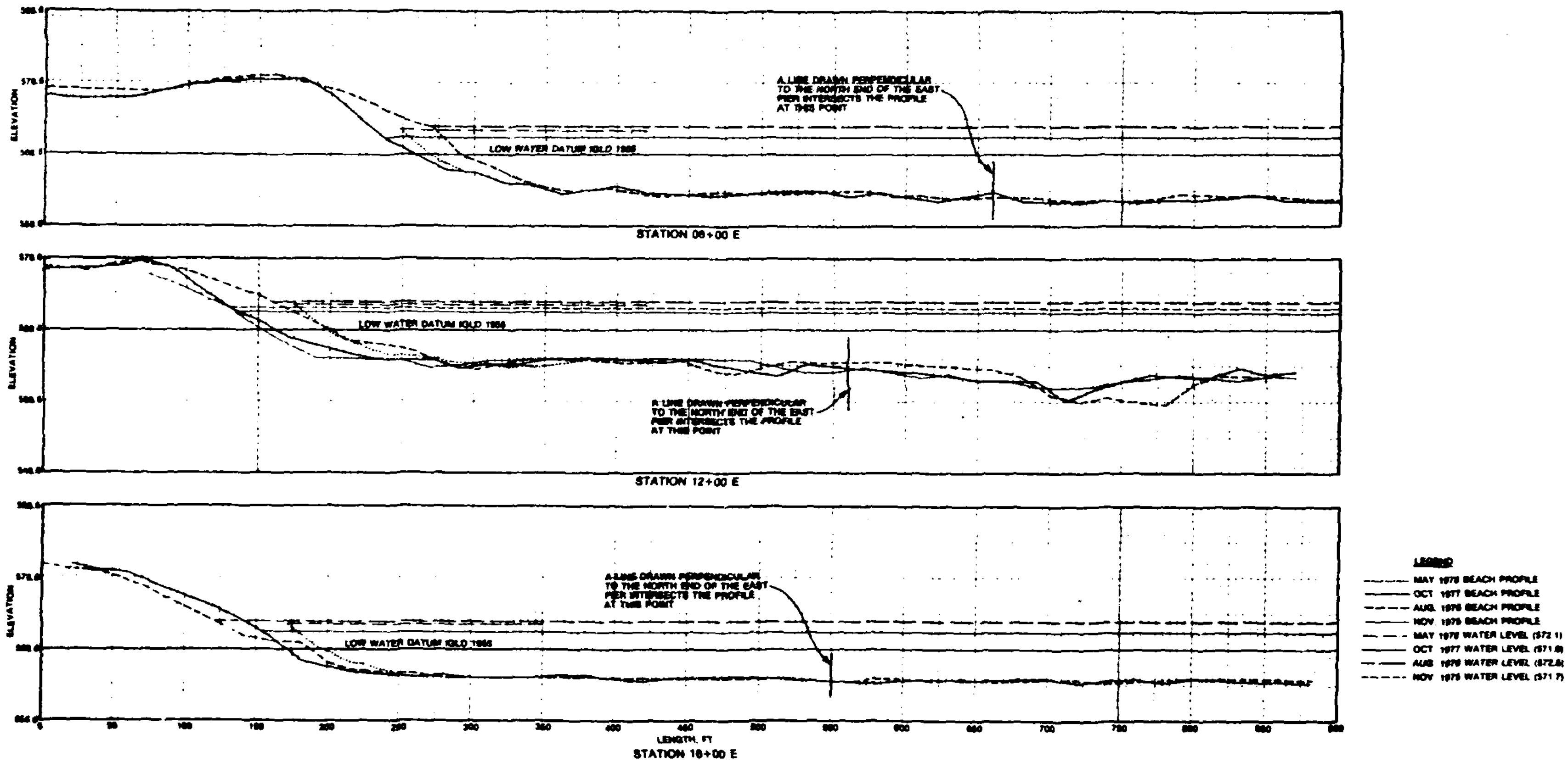


Figure 12 • BEACH PROFILES - STATIONS 8+00 E, 12+00 E, 16+00 E

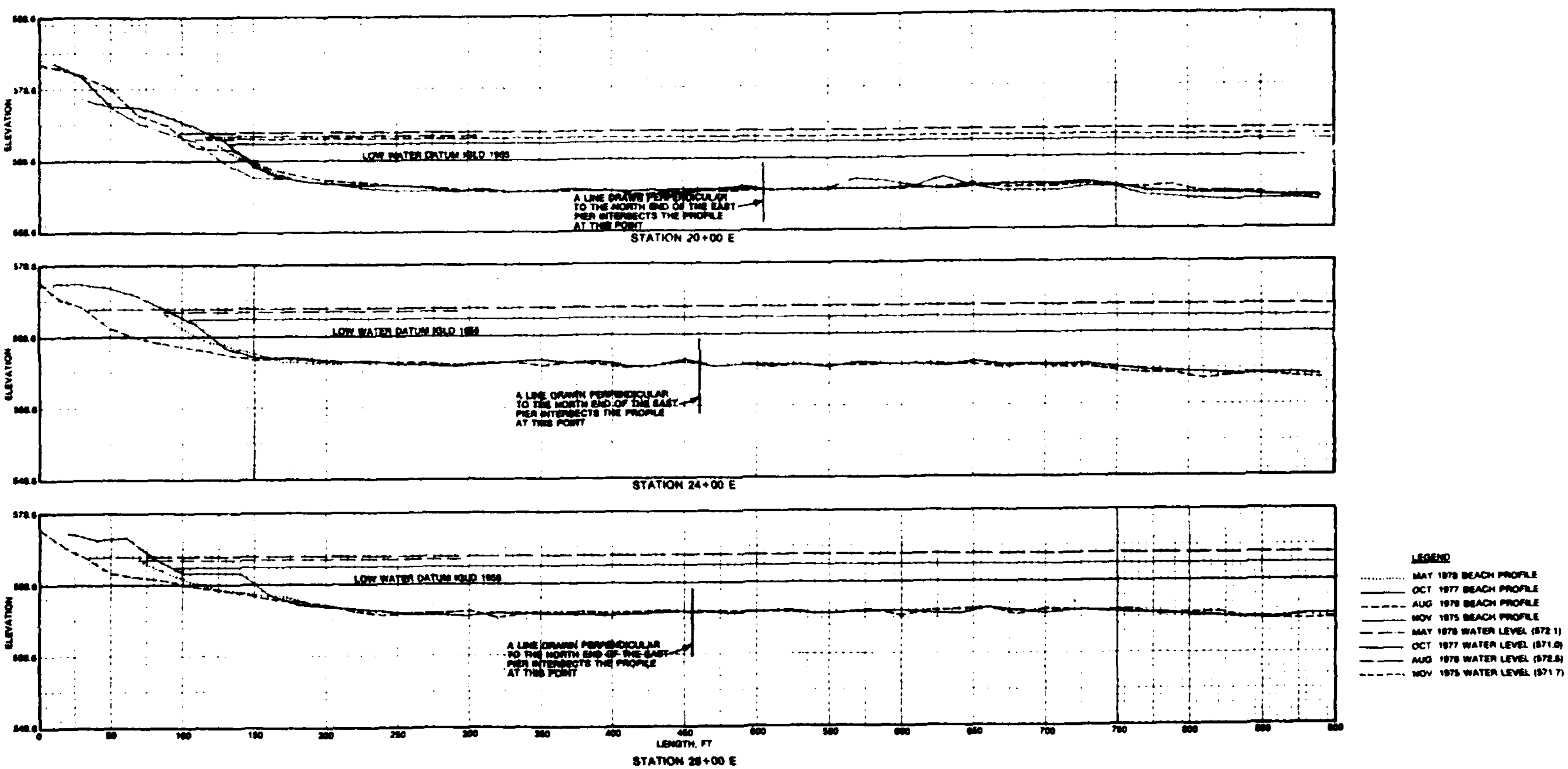


Figure 13 • BEACH PROFILES - STATIONS 20+00 E, 24+00 E, 28+00 E

TABLE 3

SUMMARY OF HISTORICAL SHORELINE ANALYSIS

Station	Beach Slope	Maximum Berm Height (1) (ft)	Seaward Depth (2) (ft)	1937-1968 LWD (3) (ft)	1937-1968 Volume (4) (cu yd)	1968-1971 (5) LWD (3) (ft)	1968-1971 (5) Volume (4) (cu yd)	1971-1973 LWD (3) (ft)	1971-1973 Volume (4) (cu yd)	1973-1974 LWD (3) (ft)	1973-1974 Volume (4) (cu yd)	1974-1977 LWD (3) (ft)	1974-1977 Volume (4) (cu yd)
12+00 W	1:14	7.5	4	+30		+5		-5		-30		-15	
10+00 W	1:12	8	4	+85	+5,350	-10	-220	-10	-670	-25	-3,590	-20	-1,490
8+00 W	1:16	8	4.5	+110	+10,560	+40	+1,360	-15	-1,130	-50	-3,760	-10	-1,330
6+00 W	1:20	8	5	+65	+7,650	+110	+7,130	-40	-2,600	-15	-3,430	+15	+230
4+00 W	1:26	8	4	-395	-19,160	-25	+3,620	-60	-4,260	+20	+110	+50	+3,130
2+00 W	1:23	8	2	-300	-20,970	-190	-8,120	-25	3,210	-20	+240	+45	+4,050
0+00 E	1:14	8	14	-30		0		+110		+180		+105	
1+00 E	1:13	8.5	14	-10	-1,670	0	0	+100	+8,750	+165	+14,380	+80	+7,300
2+00 E	1:12	9	14	0	-430	-15	-640	+110	+8,940	+140	+12,990	+45	+5,330
4+00 E	1:12	10	10	-5	+1,420	-5	-2,050	+80	+14,940	+110	+19,780	+10	+4,690
6+00 E	1:11	10.5	7.5	-30	-3,330	0	-880	+60	+10,590	+55	+12,190	-10	-640
8+00 E	1:9	11	5	-25	-2,680	-10	-1,560	+40	+6,630	+45	+6,630	-5	-1,280
10+00 E	1:10	10.5	4.5	-30	-4,230	0	-290	+45	+3,940	+45	+2,960	-5	-430
12+00 E	1:10	10	4	-30	-2,720	-20	-1,230	+60	+5,440	+15	+2,750	-10	-1,240
14+00 E	1:11	11	4	+5	-1,210	-15	-1,920	+45	+5,740	-35	-1,120	-15	-1,380
16+00 E	1:12	12	4	-5	+880	-20	-2,030	+20	+3,630	-35	-3,800	-10	-2,330
18+00 E	1:11	12	4	-45	-3,550	-10	-1,780	-10	+590	-25	-3,560	+20	+590
20+00 E	1:10	12	4	-80	-7,850	-10	-890	-5	-2,220	-25	-2,960	+15	+2,380
22+00 E	1:12	10	4	-95	-9,290	-5	-980	0	-140	-40	-3,740	+15	+2,500
24+00 E	1:13	8	4	-65	-10,130	-10	-840	-25	-1,060	-35	-3,500	+30	+3,130
26+00 E	1:15	8	4	-40	-4,770	0	-220	-60	-3,690	-10	-1,670	+5	+1,340
28+00 E	1:16	8	4	-60	-3,890	+20	+440	-90	-6,450	-5	-1,000	+5	+460
30+00 E	1:16	8	4	-70	-5,250	+10	+1,330	-105	-8,560	-30	-1,000	+10	+660
32+00 E	1:16	8	4	-90	-7,110	+25	+1,670	-40	-5,890	-100	-6,000	+10	+890
34+00 E	1:16	8	4	-100	-8,890	+40	+2,560	-65	-4,110	-45	-6,340	+5	+660
36+00 E	1:16	8	4	-90	-8,440	+20	+2,670	-55	-5,780	-35	-3,560	0	+220
38+00 E	1:16	8	4	-65	-6,890	+20	+2,000	-35	-5,110	-65	-5,330	+5	+220
40+00 E	1:16	8	4	-35	-4,450	+55	+3,220	-55	-3,110	-35	-6,670	0	+220

(1) Height at onshore limit of transport - above LWD.
(2) Depth at seaward limit of transport - below LWD.
(3) Low water datum contour change over period indicated; referenced to a baseline perpendicular to the east pier - beach recession = minus, beach accretion = positive.
(4) Volume change of section 50 feet west of station to 50 feet east (Thickness of deposit in volume calculations = sum (1) + (2)).
(5) Shoreline at Vermilion City Beach affected by washout from flood of July, 1969.

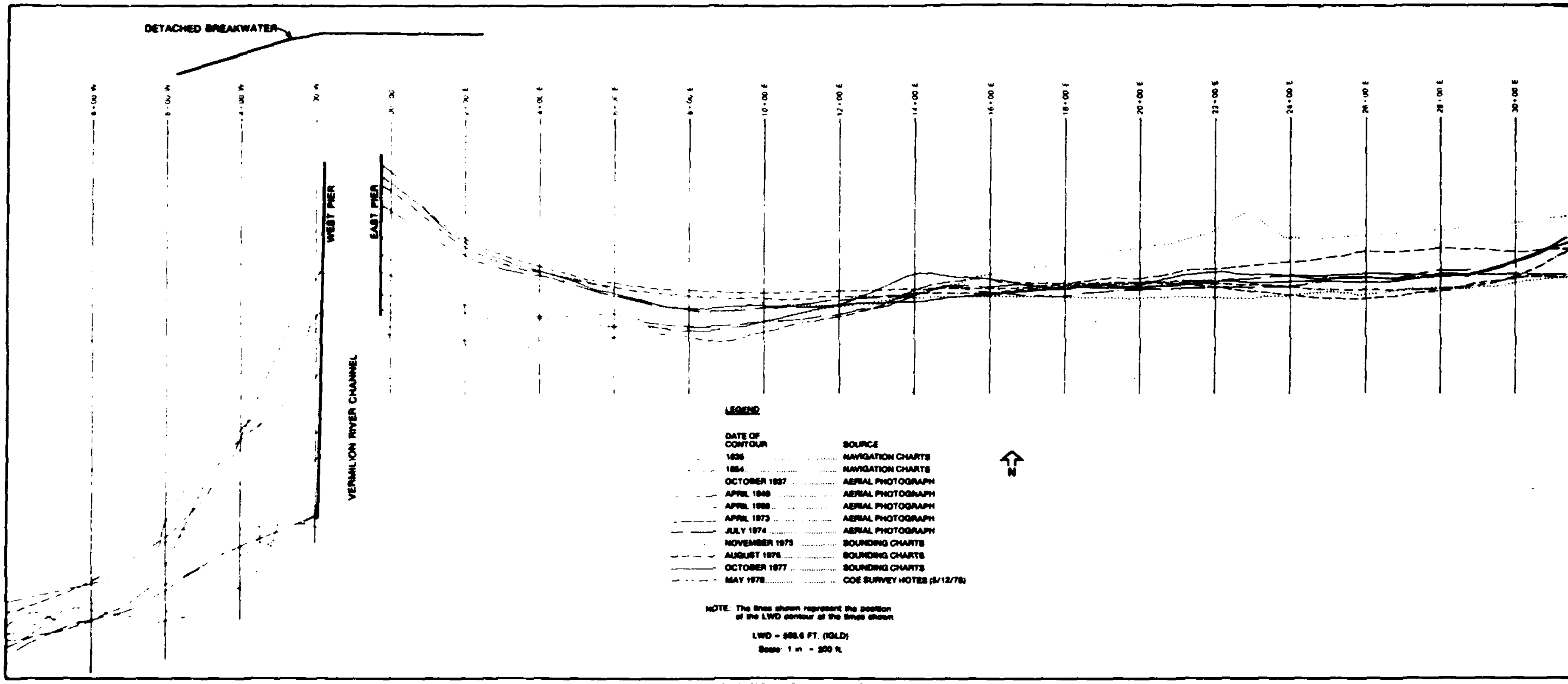
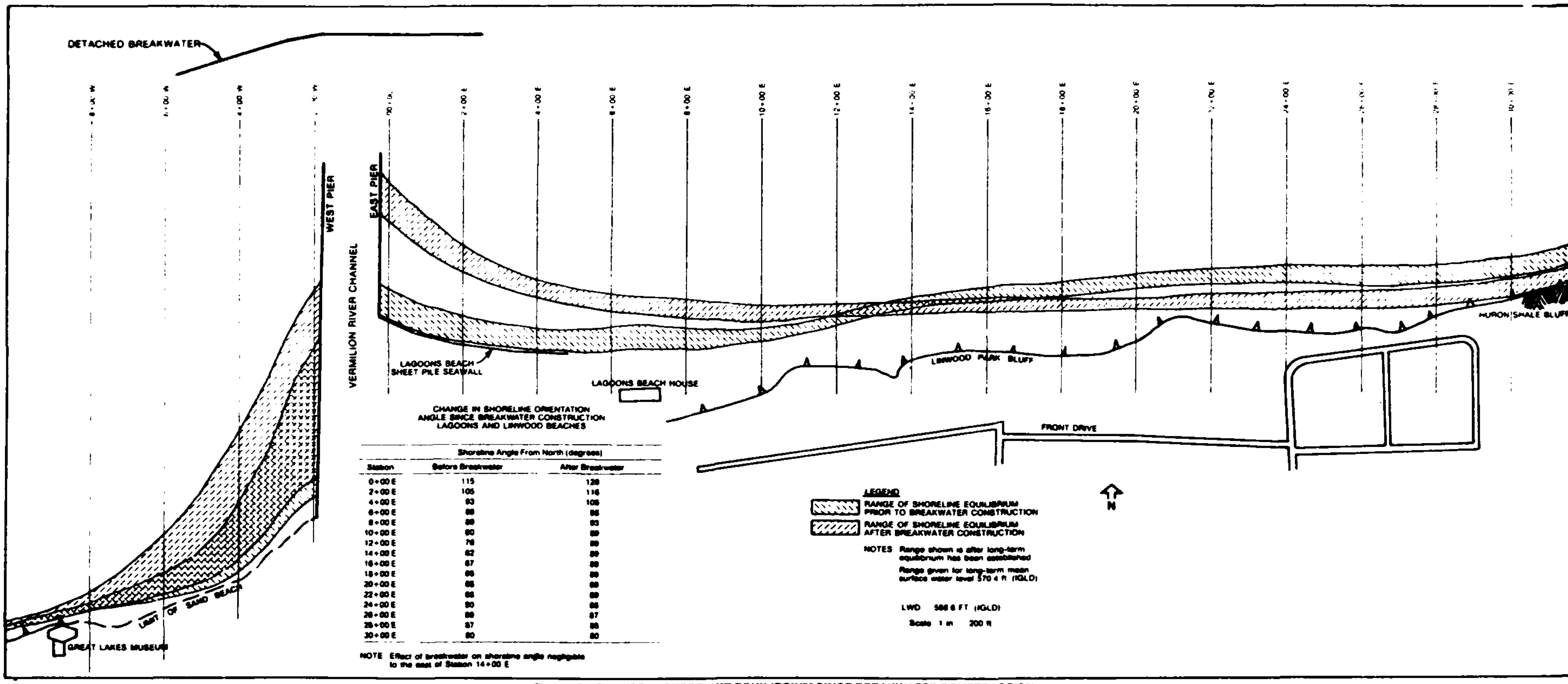


Figure 14 - HISTORICAL POSITIONS OF LOW WATER DATUM CONTOUR



CHANGE IN SHORELINE ORIENTATION
ANGLE SINCE BREAKWATER CONSTRUCTION
LAGOONS AND LINWOOD BEACHES

	Shoreline Angle From North (degrees)	
Station	Before Breakwater	After Breakwater
0+00 E	115	120
2+00 E	105	116
4+00 E	93	106
6+00 E	88	95
8+00 E	88	93
10+00 E	80	89
12+00 E	78	89
14+00 E	82	89
16+00 E	87	89
18+00 E	86	89
20+00 E	86	89
22+00 E	86	89
24+00 E	90	88
26+00 E	89	87
28+00 E	87	86
30+00 E	80	80

NOTE Effect of breakwater on shoreline angle negligible to the east of Station 14+00 E

Figure 15 • CHANGE IN SHORELINE EQUILIBRIUM SINCE BREAKWATER CONSTRUCTION

section of the beach adjacent to the pier. Examination of the data indicates that the low water datum contour reached its farthest seaward point in 1976, marking a large accretion since 1974. Until this accretion, the shoreline apparently was fairly stable since 1854, when the earliest survey was taken.

On the eastern side of the piers, accretion is also evident, beginning prior to 1973. The middle portion of the beach, from station 10+00E to 20+00E, has been fairly stable, with slight erosion in recent years. From station 20+00E to the bluff at Nakomis, erosion began in the period from 1971 to 1973 and continued until 1976. Some accretion developed between 1976 and 1977.

It should be noted that the earliest sounding data available is from 1854. Prior to construction of the U.S. piers in 1836, a continuous beach existed across the river mouth. The precise north-south position of this shoreline has not been accurately documented, although it has been reported(1) that the east shoreline accreted 500 feet from 1837 to 1847. The location of the 1835 shoreline shown on Figure 14 is estimated from a poorly referenced historical chart. Significant erosion of the shore to the west of the piers no doubt occurred. No quantitative estimates have been possible regarding this significant alteration of the coastline.

Volumetric Analysis - In order to determine historical patterns of accretion and erosion along the beaches of interest, the change in volume of material was calculated for several periods. The computations were performed at 100-foot intervals using the average end area method. Insufficient data was available to quantify changes prior to 1937. The periods for analysis were selected to demonstrate when significant changes occurred. Some trial and error was involved in determining the optimum time intervals given previously. The changes in beach volume by station are summarized in Table 3.

Areas where accretion or erosion occurred over the stated period are easily noted from the data. These locations were quantified by summing the values over the eroded or accreted reach. In this manner, the overall magnitude of deposits or erosion was determined. Figure 16

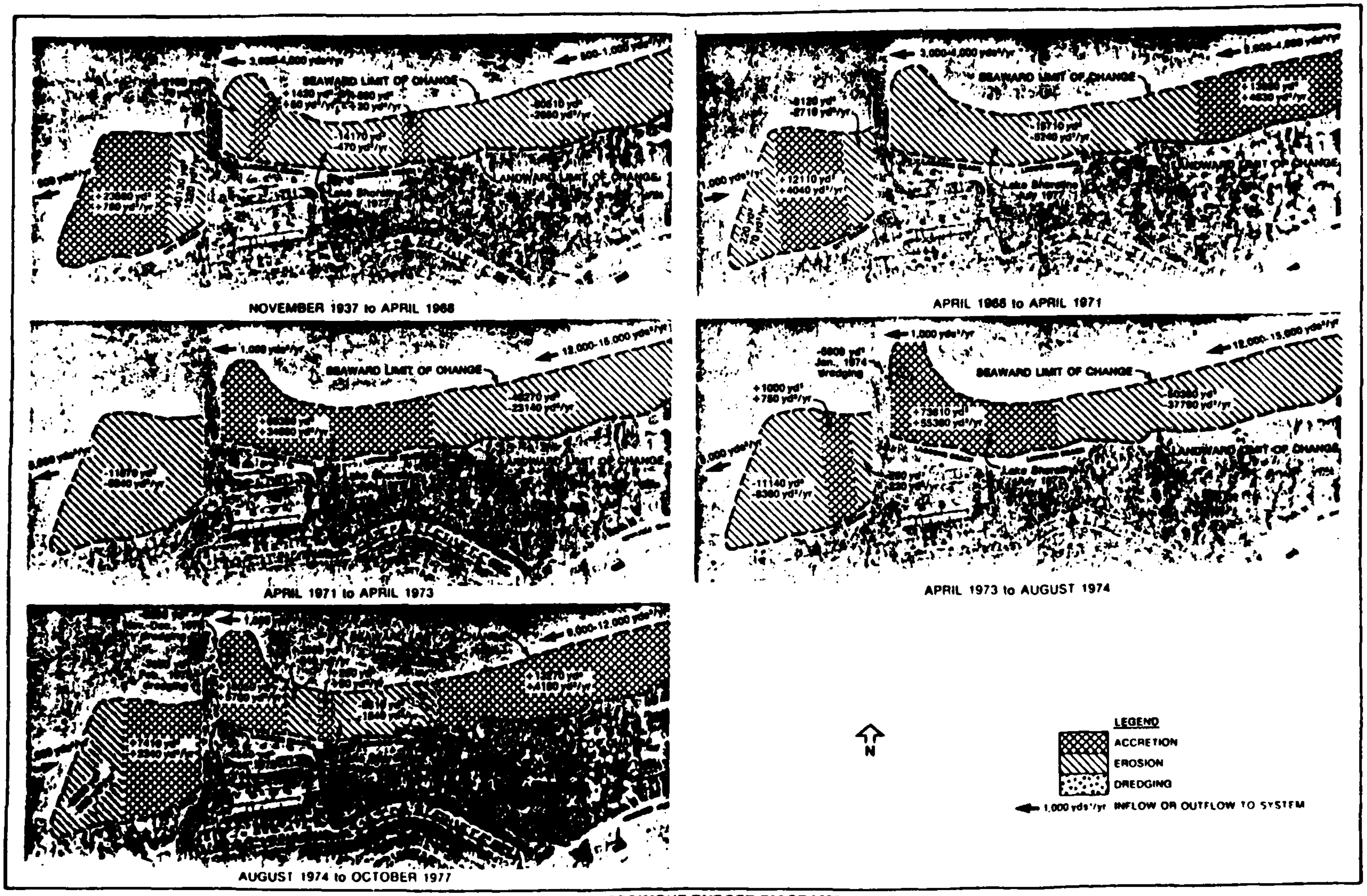


Figure 16 • SEDIMENT BUDGET DIAGRAMS

shows these areas for the five periods of interest. Sand entering or leaving the system is also indicated. The result is a sediment budget diagram for each of the five periods. The outline of the area shows the general extent of influence, but is not intended to represent the precise limits. The estimated accuracy of the computations are plus or minus 20 percent. Several assumptions were made in developing the sediment budget.

1. Wind transport is negligible.
2. Onshore-offshore transport is sufficiently small that it can be ignored. The hard bottom offshore supports the validity of this assumption.
3. Sand entering the system was estimated based on erosion of the bluffs to the east.

The following brief discussion, presented by time increment, summarizes the important points.

Changes from 1937 to 1968 - Over this 30 year period, slight erosion predominated. This material is either lost offshore or transported to the west around the piers. It must be emphasized that only a net effect over the 31-year period is presented. Undoubtedly, periods of accretion occurred during this time, but were offset by larger erosion periods. The net erosion for the beaches east of the harbor averaged 3,000 cubic yards per year. To the west of the harbor, erosion exceeded accretion by approximately 500 cubic yards per year. These amounts are both considered to be small in relation to the overall size of the beach. The values for the western beaches are affected by minor dredge and fill operations, the extent of which is unknown.

During this period, lake levels varied widely, with low levels prevalent in the mid-1960's. From 1937 to 1968, it is estimated that an average of 500 to 1,000 cubic yards per year of beach-building material entered the eastern beach system, based on estimates of erosion rates of one foot per year for the bluffs to the east. In order to account for all the sediment, approximately 4,000 cubic yards per year

of material must be lost offshore or around the east pier. Quantitative methods are not available to accurately compute losses of this magnitude. Onshore-offshore motion of sediment is not thought to be significant, since sand is essentially absent from the offshore area. It is therefore assumed that this component is negligible, and 4,000 cubic yards are lost around the piers to deep water. However, it is recognized that even very small onshore-offshore movements can significantly affect the sediment budget due to the relatively small numbers involved. For example, 2,000 cubic yards of sand moving onshore or offshore at Linwood Beach would be undetectable from soundings, since a thickness of less than 1/2 inch would result over a 2,000 by 500 foot area offshore. Likewise, the magnitude of sediment influx from the east (or west) is similarly uncertain. In summary, the accuracy of the sediment budget is therefore of the order of plus or minus 3,000 to 5,000 cubic yards per year. There is no evidence that material was moving to the east around the west pier.

It is apparent that no significant areas of accretion or erosion occurred during the overall period from 1937 to 1968.

Changes from April, 1968 to April, 1971 - Stable conditions again prevailed during this period, with slight accretion on the west beaches (700 cubic yards per year) and slight erosion (800 cubic yards per year overall) on Lagoons and Linwood Beaches. A shift in the distribution of sand from west to east occurred on the eastern beaches, indicating a predominance of westerly waves.

The sediment budget was formulated using the same approximation of sediment loss around the piers. Approximately 2,000 to 4,000 cubic yards influx from the east is then required. A bluff erosion rate of two to three feet per year would supply this amount. Although no data is available, this higher erosion rate is consistent with the higher than average lake levels.

Changes from April, 1971 to April, 1973 - A significant shift in beach alignment occurred during this period prior to breakwater construction. An average of 23,000 cubic yards per year eroded from Linwood

Beach and accreted at the east pier. An additional 11,500 cubic yards per year accreted at the east pier, indicating an increase in sediment supply from the east (or offshore). It has been reported that erosion of the shale bluffs of up to 10 feet per year has occurred during the very high lake levels[6], which could result in an influx of up to 15,000 cubic yards per year from the east.

Erosion of Vermilion City Beach at a rate of 6,000 cubic yards per year also occurred during this period, suggesting that a higher frequency of northeast waves may have occurred (see Section IV).

Changes from April, 1973 to August, 1974 - The shift in Linwood Beach from east to west continued at a slightly higher rate after the breakwater was constructed in mid-1973. Over 73,000 cubic yards of material accreted in the 17 month period. As in the previous two years, sediment budget considerations indicate that large amounts of sand (12,000-15,000 cubic yards per year) enter the system from the east.

During this period, sand deposits extended north along the east pier and spilled into the east lake approach channel, requiring dredging in July, 1974. The shoaling of the lake approach channel is likely due to the breakwater preventing northwest waves from moving sand back east onto the beach.

At Vermilion City Beach, erosion continued to predominate (5,000 cubic yards per year) indicating westward transport. Some minor accretion did occur near the west pier, as a result of breakwater shielding waves from the northeast.

Changes from August, 1974 to May, 1978 - During this most recent period, the shifting of material from east to west decreased significantly, and some accretion occurred from station 18+00E to the east end of Linwood Beach (approximately 4,000 cubic yards per year). Minor erosion occurred from station 6+00E to 18+00E and accretion (10,000 cubic yards per year) continued to occur although at a decreased rate adjacent to the pier. Analysis of the beach profiles

taken adjacent to the east pier in 1975, 1976, 1977, and 1978 indicate that accretion of this area essentially stopped in 1976.

At Vermilion City Beach, accretion occurred adjacent to the west pier at a rate of approximately 2,000 cubic yards per year. The data from both beaches indicate that the predominant wave energy may have shifted back to the northwest during this period. This aspect is investigated in Section IV.

Sediment budget inflow and outflow indicated a continuation of high sand influx to the eastern beaches. It is reiterated that these values are only approximations. It is noteworthy, however, that significant sources of material for the Linwood and Lagoons Beaches appear to exist.

Evaluation of Lake Level

An important factor in the evaluation of the impact of the breakwater on shoreline phenomena is the effect of high lake levels on shoreline erosion. It is well-known that higher lake levels increase erosion by permitting storm waves to attack further inland, often past the protection of a beach. The breaking wave characteristics may also be altered, since larger waves can now exist in the deeper water. The critical point in this analysis is the differentiation between shoreline erosion and redistribution effects due to construction of the offshore breakwater (1973) and the effects of concurrent record high lake levels in 1972 through 1975.

One possible method of assessing the effect of high lake levels involves use of a cumulative volume balance to determine how much of the shoreline redistribution on the eastern beaches was due to the offshore breakwater. This procedure involves summation of the accretion and/or erosion values as a function of distance east from the east jetty. The assumption must be made that the Lagoons-Linwood Beach system is essentially closed, with little sediment inflow or outflow. Unfortunately, the analysis of historical data indicates that the system is not closed. Significant, highly variable amounts of net erosion or accretion occur

for the 3,000 foot section of beach during various time intervals. A cumulative volume plot is therefore not considered to be useful.

One suggested method of accounting for some of the inflow-outflow of sediment is that proposed by Bruun.(7) For Bruun's analysis, two assumptions are made; the first being that a steady state of littoral transport of material passing updrift and downdrift from the section of beach profile exists; and second, that during the redistribution of sediment within the section, a conservation of mass applies. Brunn terms such conditions as an equilibrium profile. For his analysis, Bruun proposes that for a change in elevation in water level, there will be a corresponding and equal change in the elevation of the bed sediment. In periods of increase in water level, the extra material required to raise the bed elevation will be supplied by erosion of the beach and berm, while in periods of decrease in water level, excess bed material will be driven onshore to result in accretion of the beach.

Application of Bruun's analysis to Vermilion encounters inconsistencies and unique physical conditions which make its use suspect in the Vermilion situation. Significant and variable amounts of littoral drift do occur on the Vermilion beaches. This is evidenced by both erosion and accretion occurring on the same beach during a given period and by the values of longshore transport at various stations, which are given in Section IV of this report.

Bruun's analysis is intended for a gradual variation in water level over a relatively long period of time (generally stated in terms of millimeters in geologic time spans, often to thousands of years). The fluctuations of Lake Erie are frequent and substantial both on a seasonal and year-to-year basis, with the seasonal changes often being equal to or greater than those from year to year. Hence if Bruun's analysis were to hold, a seasonal fluctuation in water level of one foot would result in alternate erosion followed by accretion of the shoreline of some several hundred feet annually simply to satisfy the offshore accretion requirement. Obviously, such progression and

recession of the shoreline is not occurring and so if Bruun's analysis is to have any validity, a substantial time period is to be involved, not months or even a few years.

Bruun's analysis assumes a semi-infinite moveable sediment bed. At Vermilion, this does not exist as sediment sampling (see Figure 4) indicates that no material in the hard, fixed bed is available offshore. The sediment sampling of Vermilion shows that the sand bed only lies in a band at the shoreline.

For the above reasons, it is felt that application of the analysis by Bruun is inappropriate in the Vermilion situation.

Further consideration of lake level effects is included in the discussion of littoral processes in Section IV.

Summary

The analysis of historical information has established that a significant shift in beach material from east to west occurred from 1971 to 1976 on Linwood and Lagoons Beaches. A slight reversal occurred in late 1976 and 1977, as indicated by the beach profile and aerial photograph analysis. It is noteworthy that the accretion at the east pier and erosion at eastern Linwood Park began before the breakwater construction.

From the data available, it has not been possible to determine the relative magnitude of effects due to the high lake levels and to the breakwater. Theoretically, high lake levels should not alter the shoreline orientation (Section IV). However, high levels will increase bluff erosion, and therefore will result in an increase in the supply of sand to the Linwood-Lagoons area, as discussed in Section II. It appears that the shift in beach alignment began as a response to high lake levels and a slight predominance of northeasterly winds (see Section IV), and was accentuated by the trapping effect of the breakwater. This trapping of beach material by the breakwater occurs when sand is driven west to the piers by northeast storms and is then protected from subsequent exposure to northwest storms by the position of the breakwater. Under prebreakwater conditions, the sand would be

returned to the east by the northwest storms. The breakwater has therefore had an effect on beach orientation, resulting in shoreline recession at Linwood Beach.

The accretion of sand adjacent to the east pier reached farther north in 1976 than ever previously recorded. Dredging of the harbor approach channel at the end of the east pier and of the river channel near the east pier was required in 1974 and 1975, for the first time. These deposits are obviously related to the buildup of sand east of the east pier, which is partially caused by the breakwater.

Evaluation of the historical data indicates that the beach alignment adjusted to equilibrium by 1976, with little further change. Lake levels had receded approximately 0.5 to 1.0 feet from the record high levels of 1973. This small decrease is not likely to have significantly altered littoral processes, and does not explain the fact that the beach realignment ceased.

SECTION IV - ANALYSIS OF LITTORAL PROCESSES AT VERMILION HARBOR

Introduction

In order to provide further information regarding the causal factors involved in shoreline redistribution and transport, a detailed analysis of littoral processes was conducted. The results were then used to assist in drawing conclusions regarding expected future changes in beach alignment. The analysis involved investigation of several interrelated phenomena, including: 1) longshore transport, 2) onshore-offshore transport, and 3) sources and sinks of sediment. The methodology and significant results are summarized in this section, and the details of the analysis are contained in Appendix A.

Methodology

Longshore Transport - An estimate of the potential longshore transport of beach material was computed using the energy flux method as recommended by the Corps of Engineers Coastal Engineering Research Center.[8] The basic approach of this analysis is to compute the longshore component of wave energy that impacts upon the shoreline. The wave energy is then converted to sediment movement by empirical relationships, based either on historical data from the specific site of interest, or on generalized data from a number of other sites. It is emphasized that such calculations are only approximations of potential transport, assuming that an adequate supply of beach material exists in the littoral system.

The first step in energy flux analysis is to determine the waves that occur at the site of interest. Unfortunately, no detailed wave data was available for Vermilion. For this study, three different sources of wave information were used:

1. Wave climate developed for Lakeview Park Study at Lorain, Ohio.[9] The wave heights and periods were then transformed to reflect

the slightly different fetch distances applicable at Vermilion. The data was originally generated by hindcast methods from wind data over the three year period 1948-1950.[10] The resulting wave climate for Vermilion is shown in Table 4 (modified Lorain data).

2. Visual estimates of wave directions, heights, and periods from 1960-1973, summarized in Synoptic Summary of Meteorological Observations (SSMO).[11] This data is only given for the western half of Lake Erie, thereby limiting the accuracy when application to a specific site is made. The SSMO wave climate is given in Table 5.

3. In order to assess the waves occurring during the past 7 years at Vermilion Harbor, meteorological data[12] for these years was examined, and a wave climate was hindcast for each year. This was undertaken to determine if an atypical distribution of storms may have occurred before or after construction of the breakwater.

The wave climates generated above all give values of deep water wave heights and periods. The effect of the waves on the Vermilion beaches results from the wave height and angle of attack when the wave breaks near the shore. Wave refraction, diffraction, and shoaling affect the wave as it approaches the shoreline.

Wave refraction and shoaling occur as the waves move from deeper into shallower water. The lake bottom slows the wave and results in increased height (shoaling). Waves approaching at an angle to the bottom contours are "bent" and wave height is altered since the part of the wave closest to shore slows more than the part farther offshore (refraction). Wave refraction and shoaling were calculated using a Corps of Engineers computer program.[13] Refraction diagrams showing the behavior of representative waves from the directions of interest are shown on Figures 17-19 (1977 shoreline). Figure 20 shows the refraction for representative waves with the 1968 shoreline. The wave rays shown are perpendicular to the wave crests. Further discussion of refraction is included in Appendix A, on page A-5. The diagrams indicate the path a wave followed as it moved

TABLE 4

MODIFIED INCIDENT WAVE CLIMATE AT VERMILION (ICE FREE PERIOD)

(CORRECTED DATA FROM T.M. 37[10] 1948-1950)

H_o (ft)	Direction	Duration Given in Hours for 3-Year Period — Wave Period (sec) 1-2	2-3	3-4	4-5	5-6	6-7	Total
.5-1	W	29	81	17				127
	WNW	58	120	40				218
	NW	58	144	25				227
	NNW	51	221	12				284
	N	64	103	101	32			300
	NNE	91	43	53	84			271
	NE	48	9	9	42			108
	ENE	242	54	6				302
Total		641	775	263	158			1,837
1-2	W	26	183	52				261
	WNW	19	186	170				375
	NW	19	150	150				319
	NNW	20	279	128				427
	N	25	106	106	117			354
	NNE	8	161	154	147	1	1	472
	NE	12	68	67	96	2	1	246
	ENE	35	50	15				100
Total		164	1,183	842	360	3	2	2,554
2-3	W	2	16	20				38
	WNW		12	227				239
	NW		13	113	1			127
	NNW		5	166				171
	N	3	23	24	148			198
	NNE	1	14	29	155	6	5	210
	NE		16	17	120	14	13	180
	ENE		4					4
Total		6	103	596	424	20	18	1,167
3-4	W		3	13	2			18
	WNW		3	29	1			33
	NW		3	26	4			33
	N				24	6		30
	NNE			2	33	15	12	62
	NE				24	9	9	42
Total			9	70	88	30	21	218
4-5	W		1	3	2			4
	WNW				5			5
	NW			4				4
	NNW				6			6
	NNE			1	11	11	9	32
Total			1	8	24	11	9	53
5-6	NW		2	12				14
	NNW			6	7			13
	NE					6	6	12
Total			2	18	7	6	6	39
6-7	NNW				5			5
Total					5			5
TOTAL		811	2,073	1,797	1,066	70	56	5,873

H_o is deep water wave height.

TABLE 5

INCIDENT WAVE CLIMATE AT VERMILION
(SSMO DATA 1960-1973)

H_o (ft)	Direction	Duration Given in Hours for 3-Year Period — Wave Period (sec) 1-2	2-3	3-4	4-5	5-6	6-8	8-10	10-12	12-14	>14	Total
<1	W	98	45									143
	NW	80	59									139
	N	115	88									203
	NE	122	122									244
	E	262										262
Total		677	314									991
1-2	W	7	207	95			7	4				320
	NW	16	298	155			11	6				486
	N	29	400	214			15	8				666
	NE	10	395	402	7		19	10				843
	E	448	897				32	16				1,393
Total		510	2,197	866	7		84	44				3,708
3-4	W		10	146	22		11	8	3	3		203
	NW			318	37		21	16	5	5		402
	N		8	206	18		14	10	3	3		262
	NE		8	374	141		31	23	8	8		593
	E			200	200	13	25	18	6	6		468
Total			26	1,244	418	13	102	75	25	25		1,928
5-6	W			61	427	61	68	15			15	647
	NW			35	87	8	16	4			4	154
	N			54	136	14	25	6			6	241
	NE			39	174		26	6			6	251
	E			71	150	71	36	8			8	344
Total				260	974	154	171	39			39	1,637
7	W				143		67				15	225
	NW				78		36				8	122
	E				35		17				4	56
Total					256		120				27	403
8-9	W				20	15		20				55
	NE					24		14				38
Total					20	39		34				93
10-11	NE					14			14	14		42
	E					30			30	30		90
Total						44			44	44		132
12	NE					43						43
Total						43						43
TOTAL		1,187	2,537	2,370	1,675	293	477	192	69	69	66	8,935

H_o is deep water wave height.

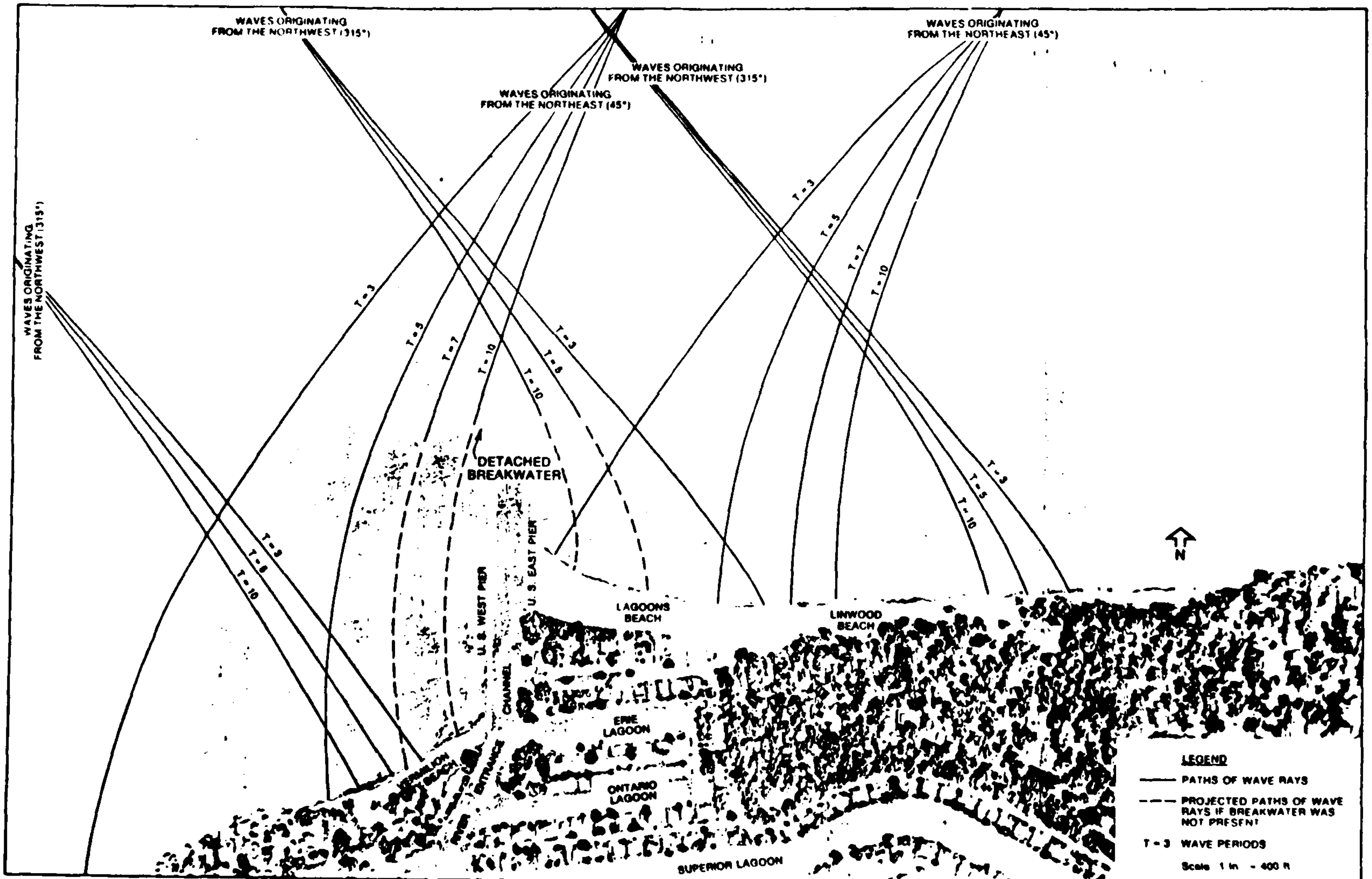


Figure 17 • WAVE REFRACTION DIAGRAMS - NORTHEAST AND NORTHWEST DIRECTIONS

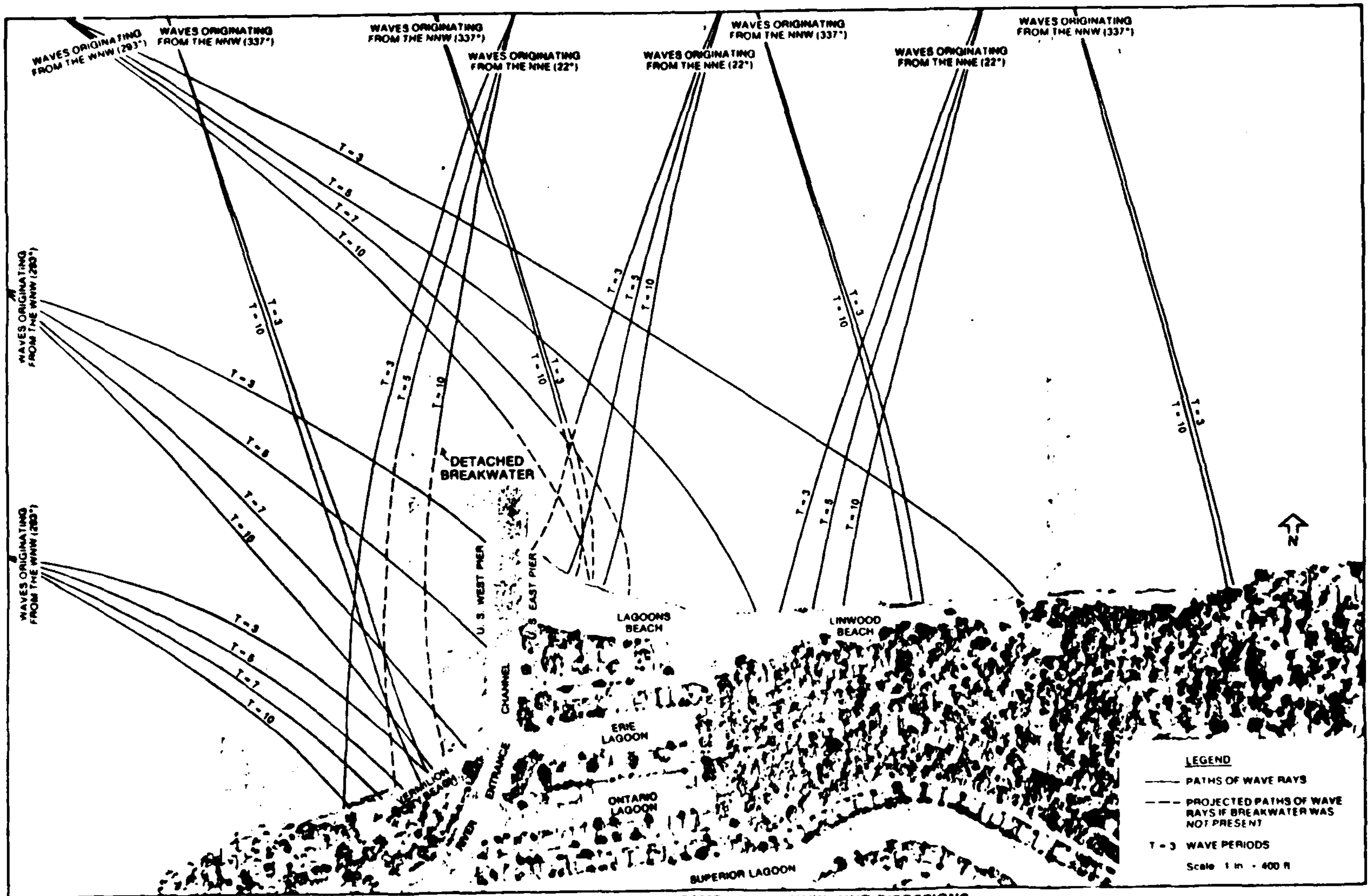


Figure 18 • WAVE REFRACTION DIAGRAMS - WNW, NNW, NNE DIRECTIONS

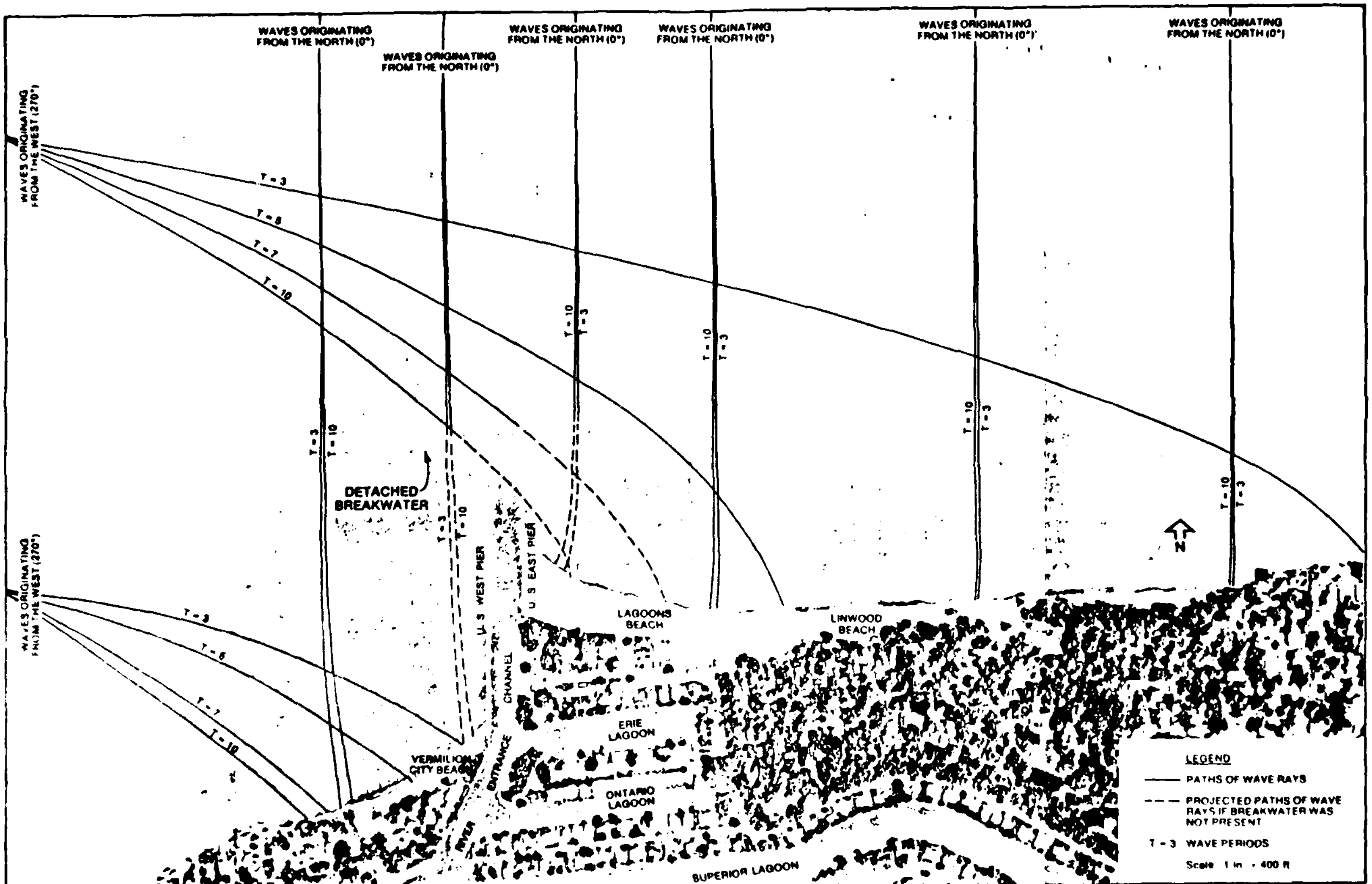


Figure 19 • WAVE REFRACTION DIAGRAMS - WEST, NORTH DIRECTIONS

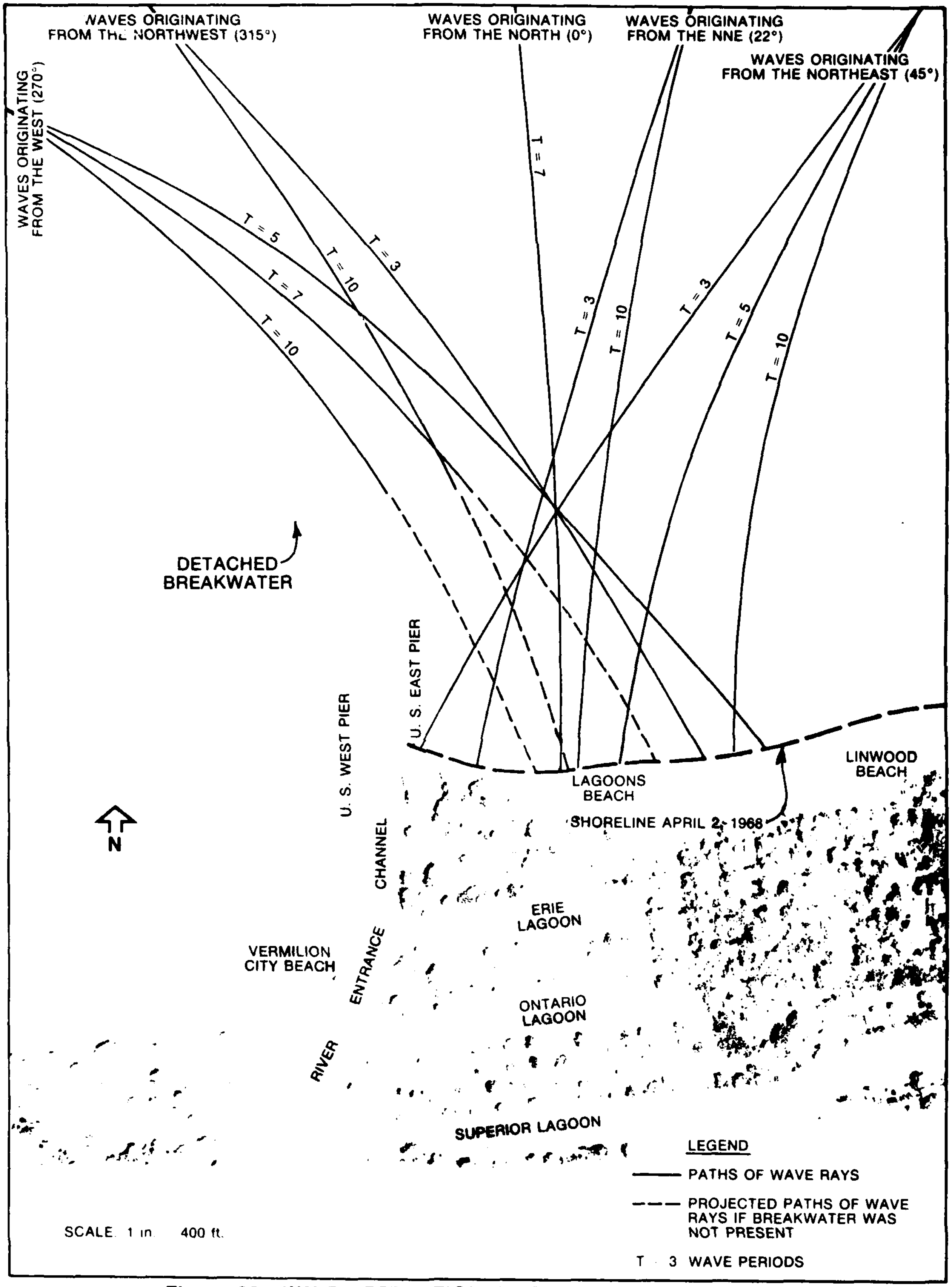


Figure 20 • WAVE REFRACTION DIAGRAM - 1968 SHORELINE

toward the beach. These paths, together with the breaking criteria discussed below, were used to compute the wave angle with respect to the shoreline at breaking (α_b).

Wave diffraction allows for the lateral transfer of energy along the wave crest and is most noticable when the waves progress is interrupted by some barrier. Such is the case with the detached breakwater and harbor entrance piers at Vermilion. Whenever the incident waves encountered these barriers, diffraction analysis was performed and included in subsequent wave energy calculations. Diffraction analysis was performed by methods outlined in SPM.(8)

The wave height and wave angle at breaking were calculated from the refraction pattern and the relationship:

$$\frac{\text{Wave height at breaking}}{\text{Water Depth}} = 0.8$$

In the vicinity of the breakwater and the piers, diffraction of waves around these structures also affects the wave angle and height. These effects were included in the analysis as well.

The resulting breaker angle (α_b) and height (H_b) were then used to compute longshore energy flux from the equation:

$$P_{1s} = \frac{\rho g}{16} H_b^2 C_g \sin 2\alpha_b$$

Where C_g = group wave speed.

The computation of energy fluxes for wave distributions presented above resulted in a net energy flux along the shore. The details of these computations are given in Appendix A.

The energy flux values were then converted to longshore sediment transport quantities by empirical formulae. The amount of sediment moved by a given wave is dependent upon sediment size, beach slope, and supply. Initially, the generalized Corps of Engineers formula $Q_s = (C)(P_{1s})$, where Q_s is the sediment transport in cubic yards per year was used. The Shore Protection Manual(8) suggests a value of 7,500 for C. However, the high values were not consistent with observed volume changes discussed in Section III. A procedure was then used to "calibrate" this equation for the Vermilion case. The basic approach was to analyze several

sections of Lagoons and Linwood Beaches where known volume changes occurred. A balance of inflow and outflow energy fluxes was set up, and a coefficient of proportionality could be found between volume change and net energy flux. Application of this procedure to several cases resulted in the following formula, which was then used in all calculations.

$$Q_s = 1940 \, P_{1s}$$

Further explanation of the computations may be found in Appendix A. For comparison, it is noted that values cited in the literature for C include 883 for the northeast coast(8) and 2,430 for the North Carolina Coast.(14)

The calculation of littoral transport was carried out for eight stations, representing the critical areas for Vermilion beaches. Two stations are on City Beach, west of the piers, and six are on Lagoons and Linwood Beaches. The locations, shown on Figure 2, were selected to ensure that some stations were in the area of the breakwater's influence (2, 3, 4, 5) and some were outside of it (1, 7, 8).

Several sets of littoral transport computations were completed, in order to assess various conditions.

Transport resulting from the modified Lorain and SSMO wave climates was computed for the following conditions:

1. 1977 shoreline with the breakwater.
2. 1977 shoreline, no breakwater.
3. 1968 shoreline, no breakwater.
4. 1968 shoreline with breakwater.

It is noted that the 1968 and 1971 shorelines are essentially the same. Therefore, the computations are applicable for 1971 as well. The effects of water level changes on transport phenomena were also evaluated for representative cases.

Additional transport analysis was conducted for the years 1971 to 1976 inclusive, and for a typical northeast storm.

Based upon the transport analysis described above, it was possible to determine an equilibrium angle for the shoreline at each station. At this orientation, no net sand transport would occur for the incident waves considered.

Onshore-Offshore Transport - Onshore-offshore transport was evaluated from a combination of theoretical and empirical approaches. The velocity required for initiation of movement of lake bed sand was computed to be about 0.4 to 0.5 feet per second.[8] (See Section II for sand particle sizes.)

The waves which result in velocities of this magnitude at various water depths were then calculated. Additional consideration of onshore-offshore transport based on the Vermilion area soundings and knowledge of other similar areas is given later in Section V.

Presentation of Results

Littoral Transport - The results of the littoral transport analysis using the modified Lorain wave climate and SSMO data are presented in Table 6.

The results indicate that the predominant direction of transport on Linwood and Lagoons Beaches is east. This is in contrast to the generally accepted east to west transport existing from Lorain to Vermilion, and on to Huron as well. It is noted, however, that the shoreline orientation along Lagoons and Linwood Beaches is roughly east-west (80°-100° from north), while the shoreline from Lorain to the Linwood area is oriented more northeast-southwest (50°-60°). It is therefore expected that westerly transport is decreased in this area, possibly resulting in a net easterly movement, in the vicinity of Lagoons Beach. Possible limitations in the accuracy of the energy-flux method are discussed later.

Prior to breakwater construction, westerly transport generally predominated on Vermilion City Beach. Results based on TM-37[10] data indicate potential transport of 15,000 to 19,000 cubic yards per year at the east end of the beach (Station 1) and approximately 50,000 cubic yards per year at Station 2. The higher amount at Station 2 results from the more northerly orientation of the shoreline at this spot. It is emphasized that the numerical values are only gross estimates of potential transport from the wave energy. Limited sand availability often reduces the actual movement drastically. For example, the analysis of historical data indicates net volume changes of only 500 cubic yards per year occurred prior to 1968. Nevertheless, westward transport is predicted for Vermilion City Beach, as expected.

TABLE 6

NET LITTORAL TRANSPORT AT VERMILION BEACHES

Condition	Shoreline	Station 1 (yd^3/yr)	Station 2 (yd^3/yr)	Station 3 (yd^3/yr)	Station 4 (yd^3/yr)	Station 5 (yd^3/yr)	Station 6 (yd^3/yr)	Station 7 (yd^3/yr)	Station 8 (yd^3/yr)
MODIFIED TM 37 WAVE CLIMATE									
No Breakwater	1977	-14,670	-45,470	+59,290	+46,770	+20,840	+32,570	+9,560	+19,440
With Breakwater	1977	+14,620	+1,750	+26,660	+14,160	-13,170	+12,280	+9,560	+19,440
With Breakwater	1968	+13,870	+1,710	+32,190	+2,480	-16,860	-19,280	+4,310	+14,430
No Breakwater	1968	-19,000	-65,150	+56,550	+52,340	+21,460	+18,410	+4,310	+14,430
SSMO WAVE CLIMATE									
No Breakwater	1977	+7,450	-13,120		+25,870		+26,250	+21,710	+22,150
With Breakwater	1977	+31,080	+12,730		+8,420		-5,810	+21,710	+22,150
With Breakwater	1968	+29,550	+12,100		-4,080		-23,660	+17,340	+19,910
No Breakwater	1968	+4,910	-18,140		+28,510		+14,910	+17,340	+19,910

+ = Transport to the east.
- = Transport to the west.

Note: Station location described in Figure 2.

Computations based on SSMO data predict easterly transport at Station 1 and westerly transport at Station 2. This apparent anomaly results from the slightly more northerly shoreline orientation at Station 2, and emphasizes the critical importance of shoreline orientation in the calculations. The net longshore energy fluxes at Vermilion are very small, and a slight difference in shoreline alignment may change the direction of littoral drift. The analytical method computes independent transport values at each point on the beach, and may not be accurate for regional drift.

On Lagoons and Linwood Beaches, the potential transport is easterly prior to breakwater construction, with magnitudes ranging from 50,000 cubic yards per year near the east pier to 5,000 cubic yards at the east end of Linwood Beach (TM-37 data). SSMO data also predicts easterly transport with a smaller range of magnitudes. Again, the easterly transport predicted is questionable, but possible in light of the shoreline alignment, although the magnitudes are likely overestimated.

After construction of the breakwater, predominant sand transport reversed to the east on Vermilion City Beach, due to the breakwater shielding the shoreline from northeasterly waves. The quantity of potential transport ranged from 2,000 cubic yards per year to 13,000 cubic yards per year (TM-37) and from 12,000 to 30,000 cubic yards per year (SSMO data). This discrepancy points out the approximate nature of the estimates. Small variations in incident wave climate may cause large changes in transport. Potential inaccuracy is introduced in the wave climate, the refraction procedure, and the general nature of the transport equations.

Significant errors are present in each wave climate studied. The TM-37 data was generated by hindcasting methods, rather than actual wave data. The SSMO data, on the other hand, is based on actual wave observations, but is generalized for the entire western half of Lake Erie. In addition, wave observations tend to overestimate heights and periods. since the larger waves of a group are noted. Several very large waves

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are included in the SSMO data (see Table 5). The modified TM-37 data is generally considered to be a better reproduction of the actual conditions.

In spite of these limitations, accretion of the beach immediately west of the west pier is predicted by the energy flux method, although the magnitude is overestimated.

For Lagoons and Linwood Beaches, the observed buildup of sand adjacent to the east pier is not predicted by TM-37 wave data. Eastward transport occurs at Stations 3 and 4, due to the shoreline alignment (>110°). Westward transport is predicted only at Stations 5 and 6. SSMO data predicts westward transport at Stations 4-6, which is in better agreement with the observed accretion at Lagoons Beach. Realignment of the shoreline (1977 computations) reversed the calculated transport to the east of Station 4 (8,400 cubic yards) and significantly reduced westward movement at Station 6 (from 24,000 to 6,000 cubic yards). The breakwater has had no significant effect on transport at or to the east of Station 7 located 1,800 feet east of the east pier. This is in good agreement with the analysis of data (Section III), which indicated that the area of influence extends only to Station 14+00 E.

In summary, the application of TM-37 and SSMO wave data failed to predict the shift in beach alignment observed from 1971 to 1975. Close examination of the wave refraction results indicates that northeast waves are refracted such that the wave breaks with an easterly component of energy at Stations 3, 4, and 5. That is, the wave ray approaches the shore west of a perpendicular to the beach (see Figure 17). Whether this is an accurate representation of refraction is questionable. It is possible that the combined effects of the breakwater, the east pier, the east lake approach channel, and the curved shoreline (and bottom contours) on wave refraction are not accurately analyzed by existing refraction theory. It appears that the limitations of the method of analysis (refraction theory and energy flux calculations) result in errors of the same general magnitude as the transport values themselves. Application of this method to open coastlines typically give transports in the hundreds of thousands of cubic yards; the percent error would be correspondingly reduced in these applications.

Lake Level Effects - The effect of a change in Lake Erie water level on wave characteristics was evaluated by computer refraction. The results are shown in Table 7. The periods shown in Table 7 are representative of the range of waves experienced at Vermilion.

TABLE 7

EFFECT OF LAKE LEVEL ON ANGLE OF WAVE BREAKING

Direction of Wave Propagation	Period (Sec) 3	5	7	10	13
	$\Delta\alpha_b{}^\circ$	$\Delta\alpha_b{}^\circ$	$\Delta\alpha_b{}^\circ$	$\Delta\alpha_b{}^\circ$	$\Delta\alpha_b{}^\circ$
West	2.25	1.00	2.00	0	0.75
Northwest	1.50	1.00	0.25	2.00	0.50
North	0	0.25	1.25	0.50	0
Northeast	1.25	1.25	1.00	1.00	0.50

Notes: α_b is the angle in degrees between the wave ray and the normal to the tangent of the shoreline.
$\Delta\alpha_b$ is the change in α_b (in degrees) caused by a 1 foot change in Lake level. Values of $\Delta\alpha_b$ are subtracted from α_b for rising lake levels, and added for falling lake levels. The figures given in the table are an average for all computed values occurring on beaches both east and west of Vermilion Harbor

A rise in water level increases refraction and results in breaking angles more perpendicular to shore. Similarly, a fall in water level decreases refraction and results in breaking angles less perpendicular to the shore (approaching the angle of wave origin). The predominant waves that are responsible for sediment transport at Vermilion are those originating in the northwest and northeast directions which are both similarly affected by variations in water level. Hence, a rise or fall in water level results in variations in gross sediment transport, but these tend to cancel and the effect on net sediment transport is not significant.

Detailed Analysis of Littoral Transport 1971-1976

Since the littoral transport computations based on historically developed average wave climates did not adequately predict observed phenomena on Lagoons and Linwood Beaches, a wave climate was developed.

for each of the years 1971 to 1976. It was observed that a slightly higher incidence of northeasterly winds occurred in 1972 and 1973. Significant wave heights and periods were hindcast from wind data taken at Cleveland. (See Appendix A for details.) The resulting littoral transport values are summarized in Table 8.

TABLE 8

NET LITTORAL TRANSPORT FOR YEARS 1971-1976

Condition	Shoreline	Station 3 (yd^3/yr)	Station 4 (yd^3/yr)	Station 5 (yd^3/yr)	Station 6 (yd^3/yr)	Station 7 (yd^3/yr)
No Breakwater	1971	+15,750	+18,040	+10,460	+7,570	+5,440
No Breakwater	1972	+21,490	+14,760	+2,820	-1,860	-510
No Breakwater	1973	+21,080	+17,560	+6,440	+3,030	-1,540
With Breakwater	1974	+9,870	+2,280	-7,790	-9,460	-2,110
With Breakwater	1975	+8,650	+3,890	-6,220	-3,810	+2,150
With Breakwater	1976	+5,670	+2,100	-6,400	-4,450	+5,280

+ = Transport to the east.
- = Transport to the west.

(Data source Local Climatological Data. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Environmental Data Service, Cleveland Hopkins International Airport, Cleveland, Ohio.)

The higher incidence of northeast winds in 1972-73 is reflected in the transport results for these years. The prevailing easterly transport is reduced during these years, and westerly transport is predicted for the eastern end of Linwood Beach. At Station 3, easterly transports are not reduced because of the previously mentioned excessive refraction at this station.

Since the breakwater was constructed in 1973, generally westward transports are predicted from Station 5 to the east until 1976. However, accretion immediately adjacent to the east pier is not predicted. Sand transport amounts during these years are significantly lower than the values predicted by TM-37 or SSMO data, and are closer to the magnitudes observed in the analysis of aerial photos in Section II. This raises a question as to how typical those wave climates are.

Potential sand transport during typical northeast storms were also calculated and are summarized below:

Date	Storm Duration	Peak Wind Velocity	Predicted Maximum Sand Transport
October 17-18, 1975	42 hrs.	33 mph	2,000 cubic yds.
April 8, 1973	33 hrs.	25 mph	750 cubic yds.
November 12 to 16, 1972*	88 hrs.	35 mph	3,500 cubic yds.

*The November, 1972-storm is well documented by Carter.[15]

It should be noted however, that because of the extreme orientation of the beach immediately adjacent to the east pier, easterly transport was predicted.

Equilibrium Beach Angles

The preceding analysis made it apparent that the angle of beach alignment was extremely critical for prediction of transport direction and magnitude. An analysis of equilibrium shoreline orientation was included in Section III (Figure 15), based on the available data. In this section, analysis of equilibrium shoreline angles is based on longshore wave energy calculations. The shoreline angle at which the net longshore sand transport is negligible was determined. The results are summarized in Table 9. A larger angle indicates a shift in sand from east to west.

It is apparent that the alignment of Vermilion City Beach is presently slightly more east-west than under equilibrium conditions. The easterly transport predicted in Table 6 will therefore continue until the equilibrium angles (64° at Station 1, 50° at Station 2) are reached.

TABLE 9

EQUILIBRIUM BEACH ANGLES[1]

Station	Predicted Equilibrium Shorelines TM-37 Data (1948-1950) Without Breakwater	Predicted Equilibrium Shorelines TM-37 Data (1948-1950) With Breakwater	Present Shore With Breakwater	Prebreakwater Shore (1968)	Predicted Equilibrium Shorelines Local Climatological Data[2] 1971[3]	1972	1973	1974	1975	1976
1	75°	64°	71°	73°						
2	69°	50°	51°	57°						
3	102°	110°	128°	118°	96°	99°	101°	111°	114°	116°
4	99°	108°	118°	102°	83°	91°	100°	112°	111°	114°
5	93°	101°	104°	90°	80°	88°	91°	106°	111°	112°
6	84°	91°	96°	87°	80°	89°	90°	101°	100°	101°
7	83°	83°	87°	85°	79°	89°	88°	88°	86°	83°

Notes: [1]Angles are taken clockwise from a north axis from the station with north = 0.

[2]U.S. Department of Commerce, NOAA, Cleveland International Airport Station.

[3]Angles shown are predicted equilibrium alignment for hindcast wave data for this year.

The present shoreline alignments of Lagoons and Linwood Beach are also more conducive to easterly transport. Several interesting points are evident:

1. The predominance of northeast winds during 1972 and 1973 are reflected in the angles for these years.
2. The effect of the breakwater was to shift the equilibrium angle by about 10° within 700 feet of the breakwater.
3. The data generated for 1974, 1975, and 1976 predicts a larger equilibrium angle (more westward transport) than TM-37 data.
4. The existence of equilibrium conditions prior to breakwater construction is evidenced by the good agreement between the 1968 shoreline and predicted values without the breakwater (Column 2).
5. Good qualitative agreement was found between the observed shoreline angle changes (Figure 15) and predicted values, although the actual orientation at Lagoons Beach is at a greater angle than predicted.

In the future, the beach should tend to decrease the angle of alignment to the equilibrium angles. This indicates that the accretion at the east end of Lagoons Beach will decrease and erosion of Linwood Beach will reverse. Indications of this occurring are evident in the 1977 survey data and photos discussed in Section II.

SECTION V - IMPACT OF FEDERAL NAVIGATION STRUCTURES

Impact on Shoreline Alignment and Beach

Distribution - The federally constructed improvements at Vermilion Harbor have significantly affected shoreline conditions in the Vermilion Harbor area, beginning with the construction of the parallel piers in 1836. Significant erosion of the western shore occurred within 10 years, and an accretion of 500 feet occurred to the east of the piers during the same period. The shoreline then stabilized at an equilibrium alignment which was maintained with little significant change until 1972. Although this initial erosion from 1837 to 1847 was substantial, no serious consideration of mitigation of these effects is warranted at this point over 130 years later.

The most recent alteration in shoreline alignment began in 1972 and continued to 1976, spanning the 1973 construction of the offshore breakwater. Although the breakwater could not have been the cause of the initial change, it appears that the presence of the structure accelerated the accretion of sand in the 800 to 1,000 foot area adjacent to the east pier by blocking the erosive power of northwesterly waves. A rigorous mathematical analysis of littoral transport does not predict a significant accretion of sand in this area. However, a shift in the equilibrium angle of the beach east of the piers of up to 10 degrees is predicted, which agrees well with the observed change.

The critical question is whether or not the shoreline will continue to accrete in the vicinity of the east pier and erode at the east end of Linwood Beach. Recent surveys and photos indicate that no further re-orientation of the shoreline has occurred since 1976. In fact, some accretion has occurred at the east end of Linwood Park (see Figures 14 and 16), probably resulting from incoming sand from the east. No recent significant reduction of the accreted deposit at the east pier is evident, however.

The mathematical analysis of littoral processes predicts that eastward transport should occur, and some reversal of the 1972-76 pattern would be expected. The future shoreline alignment may also be affected by unusual wind distributions.

After consideration of all the factors involved, it is our opinion that no further clockwise shift in shoreline orientation is likely.

Impact on Sediment Budget

As discussed previously, the influx and outflow of sediment to the Lagoons-Linwood Beach system is very difficult to evaluate. Inflow from the bluff to the east can vary from 1,000 cubic yards of beach building material per year to over 15,000 cubic yards per year depending on erosion factors such as storm incidents and lake levels. These rates have not been affected by the federal navigation structures.

The movement of material onshore or offshore also can not be ascertained with any degree of accuracy. The lack of sand presently existing offshore at depths greater than 5 to 6 feet indicates that the importance of onshore-offshore movement is negligible except in the vicinity of the river, where river discharges may have diverted littoral material offshore. However, sand thicknesses up to an inch or two would be undetected by surveys, and yet could represent a significant volume over the 3,000 foot length of Linwood Beach.

Flow of sand around the ends of the harbor channel piers is also impossible to predict. From sediment budget considerations, values on the order of 1,000 to 4,000 cubic yards per year seem reasonable. There is no evidence that westerly sand transport around the piers has increased since construction of the breakwater. However, deposits of sand have occurred in the river and lake approach channels, requiring dredging on three occasions (see Figure 16). These deposits are created by sand transport from short-term wave events. Specific storms move sand into these areas, and the breakwater prevents waves from

returning the material to the littoral system. High river flows may have also scoured sand from deposits at these locations and transported it out the east lake approach channel, resulting in loss of material to deeper water. The channel deposits in the lake approach channel and river channel are caused by the offshore breakwater.

Environmental Effects of Shoreline Erosion

The following discussion focuses on the potential environmental impacts of shoreline erosion. Impacts on the aquatic biology, water quality, terrestrial ecology, and socioeconomics are of primary concern.

Sediment resulting from shoreline erosion has a detrimental effect on aquatic biology. Siltation and turbidity lessen light penetration of the water and blanket plants, phytoplankton, and benthos with a layer of silt. These circumstances result in a lack of vegetation and pollution tolerant benthos. The lack of vegetation results in increased turbidity and a reduction in fish species which use areas of aquatic vegetation for feeding, spawning, and protection. Studies performed by Ryclaman, Edgerly, Tomlinson and Associates and the Cleveland Environmental Research Group in 1975; and by the Ohio EPA in 1972, document these conditions in the Vermilion area.[16]

As the bluff is eroded, trees are undermined and fall into the lake. Loss of this habitat is expected to have little overall effect on terrestrial wildlife since existing habitat quality is generally poor. The aesthetic impact from the loss of trees probably is more significant than the loss of habitat.

Aesthetic impacts include not only the adverse visual impact of the absence of the trees, but also the undesirable brownish color of the water due to turbidity when severe erosion occurs. Such adverse visual impacts can degrade the recreational experience for swimmers, boaters, and sightseers.

Another consideration of shoreline erosion is social well-being. Property owners living near the bluff undoubtedly have a concern for the future of their land and structures. The psychological impact of these concerns cannot be measured. In addition to these psychological concerns is the question of property values for those parcels adjacent to the eroding bluff. Physical loss of property from erosion and the impending threat to structures could depress property values.

General Alternatives for Mitigation

In the event that a decision is made to restore the Lagoons-Linwood Beach system to its pre-1972 condition, several alternatives should be investigated. They basically fall into three categories.

1. Alteration of the breakwater.
2. Artificial transport of sand.
3. Construction of shoreline protection structures along the Lagoons-Linwood shoreline.

Artificial transport of sand could be employed to move sand accreting at the east pier back to the Nakomis area. The resulting shift in shoreline alignment would restore westerly transport and distribute sand along Linwood Beach. A "littoral cycle" would be formed in which hydraulic pumping or trucking of sand would augment natural processes. The details regarding maintenance intervals and quantities moved could be designed based on sand volumes presented in Section II.

Artificial nourishment of Linwood Beach from an external sand source could be combined with bypassing at the east pier. Sand would be added to the littoral system, with some benefits for shoreline residents east and west of the harbor. The major benefit would be a larger beach at Linwood. The feasibility of such a scheme depends upon the cost of outside sand.

A variety of shoreline protection structures designed to retain sand could be considered including:

1. Groin fields of various designs.

2. A system of offshore breakwaters.

These solutions would have additional environmental and hydraulic effects, and careful evaluation would be necessary.

Conclusions

The preceding analysis has shown that the offshore breakwater has contributed significantly to shoreline re-orientation, characterized by accretion near the piers and erosion at eastern Linwood Beach. However, the shoreline is approaching a new equilibrium and no further significant shifts are anticipated. It has not been possible to quantitatively determine how much of the realignment was due to high lake levels and a higher incidence of northeast winds, and how much was due to the offshore breakwater.

The breakwater has created sand deposits in the lake approach channels and the river entrance channel. Mitigation of these impacts has been practiced in the form of maintenance dredging on three occasions. Dredging or some other form of mitigation may be required in the future for removal of similar deposits.

The tradeoff between navigation protection and coastal processes impacts is apparent. Any structure that reduces wave action to aid navigation also reduces the motive force that maintains shoreline equilibrium. Only removal of the breakwater will be completely effective in returning the shoreline to the pre-1972 long term equilibrium position. Partial modifications may also be investigated, but it is doubtful if any solution which retains significant protection for navigation would do much for restoration of the shoreline.

As stated above, the offshore breakwater has provided protection from high waves at the harbor mouth, and has had an adverse impact on shoreline re-orientation and erosion at the east end of Linwood Beach. However, the apparent relative stabilization of the shoreline at its 1976

alignment leads to the conclusion that no additional significant erosion of the beach is likely. It is emphasized that minor short term fluctuations in orientation continue to occur as a result of storms, and beach width varies with lake level. The bluff may continue to erode when storms occur during high lake levels, even though the beach remains in a long-term equilibrium position. Therefore, assuming that the beach is acceptable as it presently exists, no further consideration of mitigation for beach erosion is required. It is recommended, however, that periodic monitoring of the beach be continued so that any future unanticipated re-orientation of the shoreline is promptly recorded.

Impacts Investigated and Conclusions Reached in Companion Study

The purpose of this study was to determine whether or not the detached breakwater at Vermilion Harbor, Ohio, is causing any adverse effects for which mitigation measures should be considered. The study was initiated in April 1977 in response to complaints from the Linwood Park Cottage Owners Association and other citizens concerned about specific subjects.

The seven specific subjects of complaint addressed in this report are:

a. Periodic contamination of municipal water supply.

b. Diversion of Vermilion River water into and pollution of adjacent recreational swimming areas.

c. Increased (or decreased) ice formation in the calm waters shoreward of the breakwater at the harbor entrance and increased (or decreased) probability of ice jam flooding.

d. Increased flood potential due to raising the river water profile.

e. Rapid sediment accumulation in the Vermilion River causing increased dredging costs and increased sedimentation in the adjacent private lagoons

f. Navigation hazards due to traffic congestion at the river mouth and at blind corners.

The results of this study are that the breakwater is having an adverse effect on: (1) the recreational swimming areas to the east by diverting polluted water to them; and (2) on the ice jam flooding by increasing ice jam potential at the harbor entrance. Additional studies will be undertaken to quantify the severity of these impacts and recommendation of a mitigation plan, if warranted, will be made.

Results regarding sediment accumulations in the river are related to the shoreline erosion and redistribution of sand to the east and west of the harbor. The conclusions have been presented in this Section.

It was concluded that the breakwater is not having a significant effect on the following items:

1. Periodic contamination of the municipal water supply.
2. Increased flood potential due to raising the river water surface profile.
3. Navigation hazards due to traffic congestion at the river mouth and at blind corners.
4. Aesthetics.

Therefore, no further consideration of mitigation for these aspects is warranted.

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APPENDIX A

DEVELOPMENT OF LITTORAL PROCESSES ANALYSIS

APPENDIX A

DEVELOPMENT OF LITTORAL PROCESSES ANALYSIS

Introduction

This appendix discusses the detailed methods of analysis of littoral processes outlined in Section IV. The following basic steps are involved.

1. Development of Wave Climates
2. Refraction and Diffraction Analysis
3. Determination of Breaking Wave Height and Angle of Attack on Shoreline
4. Calculation of Energy Fluxes
5. Calculation of Sand Transport
6. Determination of Shoreline Equilibrium

1. Development of Wave Climates

Of the three wave climates developed in this study, two were constructed by using hindcast techniques, or adapted from wave climates developed in this manner. The Lakeview Park study at Lorain, Ohio[9] and the Local Climatological Data[12] for Cleveland, Ohio, were the basis of the hindcast wave climates. The third wave climate developed made use of reported observations summarized in Synoptic Summary of Meteorological Observations.[11]

Hindcasting techniques for predicting the wave height and wave period make use of the fetch length, wind velocity, and depth of water through which the wave is propogating. Methods of hindcasting are outlined in CERC "Shore Protection Manual." For the analysis in this report use was made of the following equations:

$$\frac{gH}{U^2} = 0.283 \tanh \left[0.530\left(\frac{gd}{U^2}\right)^{0.75}\right] \tanh \left\{ \frac{0.0125\left(\frac{gF}{U^2}\right)^{0.42}}{\tanh \left[0.530\left(\frac{gd}{U^2}\right)^{0.75}\right]} \right\}$$

to calculate the wave height H

7027

and

$$\frac{gT}{2\pi U} = 120 \tanh \left[0.833\left(\frac{gd}{U^2}\right)^{0.375}\right] \tanh \left\{ \frac{0.077\left(\frac{gF}{U^2}\right)^{0.25}}{\tanh \left[0.833\left(\frac{gd}{U^2}\right)^{0.375}\right]} \right\}$$

to calculate the wave period T

where: g = acceleration due to gravity (ft sec^{-2})

U = wind speed (ft sec^{-1})

d = water depth (ft)

F = fetch (ft)

H = wave height (ft)

T = wave period (sec)

Computed values of H and T by hindcast techniques generally yield results in terms of the significant wave height (Hs) and significant wave period (Ts) which is the average of the highest third of wave heights and wave periods in the wave spectra. To obtain a true range of values of waves within the spectra, it is necessary to distribute the significant wave heights and periods; this is generally achieved by use of the Rayleigh distribution of wave energy.

The above analysis had been performed in the Lakeview Park Study[8] (based on TM-37[10]) *to obtain their wave climate.* In order to apply this wave climate to the Vermilion study, it was necessary to make some adjustments to compensate for the change in fetch length brought about by transposing the site from Lorain to Vermilion. The Lorain wave climate gave the duration in hours that waves in a certain period and height range occurred and by backworking the hindcast method, the wind climate that produced the Lorain waves was established. With these winds, a wave climate for Vermilion was developed. It was also necessary to add waves originating in the east-northeast direction for Vermilion and, as no such waves exist at Lorain, the wave climates developed for Cleveland in TM-37[10] were applied.

For the wave climates developed by Local Climatological Data,[12] a statistical distribution of wind velocity and direction of origin was calculated. The hindcast techniques were applied to these wind climates to establish significant wave height (Hs) and wave period (Ts), giving a table of duration in hours that waves of Hs and Ts occur (a significant wave climate).

The Rayleigh distribution was applied to give the true wave distribution in several instances and wave energy computed to determine the relationship between significant and true wave climates. In all cases, it was found that the significant wave energy was approximately twice that calculated for the true wave climates. Calculations performed using Local Climatological Data considered only the significant wave climates noting that the differences between that and the true wave climate would be accounted for in the calibration of wave energy flux to littoral transport for Vermilion discussed later.

The wave climate from the Synoptic Summary of Meteorological Observations[11] was based on direct observations reported for the western half of Lake Erie. The wave climate was compiled by combining the wind speed-direction observations to the windspeed-wave height observations, to the wave height-wave period observations. Hence, the proportion of wind at a given speed and given direction was related to the proportion of waves of given height resulting from the wind speed and finally waves of given periods were related to the wave heights.

Differences in the three wave climates can best be observed by considering the distribution of waves within the climate. The primary variation between climates is the proportion of time that is considered calm (when wind velocity is less than four nautical miles per hour resulting in waves with a wave height less than 0.5 foot and wave period less than one second). For the modified Lakeview data (TM-37), calm periods exist 46.2 percent of the total time, which is considerably

higher than the 13.5 percent of total time found for Local Climatological Data (LCD), and the 3.4 percent of total time found for SSMO. As both TM-37 and LCD data rely on hindcast techniques from direct wind speed and direction recordings, some degree of similarity is to be expected. As this does not occur, and as the LCD data has been verified, a question arises as to the validity of the TM-37 data as a typical, average year representation.

Related to the proportion of calm conditions is the proportion of time when waves are coming from the onshore directions (west, northwest, north, northeast). Wave occurrences from these quadrants are 20.7 percent for TM-37, 32.6 percent for LCD, and 41.0 percent for SSMO, of the total time. The distribution of waves by direction within each data source shows more occurrence of waves from the west in TM-37 and SSMO and a greater occurrence of waves from the northeast quadrant in LCD data (1972 and 1973, in particular). The distribution of waves by direction is given in Table A1.

TABLE A1

WAVE DISTRIBUTION

Direction of Wave Origin	TM-37[1] (1948-1950)		SSMO[2] (1960-1973)		LCD[3] (1971-1976)	
	Percent Observations[4]	Percent Total[5]	Percent Observations	Percent Total	Percent Observations	Percent Total
W	8.3	1.7	32.2	13.2	10.5	3.4
WNW	15.9	3.3			11.2	3.7
NW	13.0	2.7	18.8	7.7	11.9	3.9
NNW	16.2	3.4			13.7	4.5
N	14.9	3.1	19.8	8.1	16.5	5.4
NNE	19.1	3.9			17.3	5.6
NE	10.4	2.1	29.2	12.0	11.7	3.8
ENE	2.2	0.5			7.2	2.4
TOTAL	100.0	20.7	100.0	41.0	100.0	32.6

[1]Lakeview Park Study at Lorain, Ohio(8) (adapted from TM-37(10)).

[2]Synoptic Summary of Meteorological Observations.(9)

[3]Local Climatological Data, U.S. Department of Commerce, NOAA.(10)

[4]Percent of the number of waves observed.

[5]Percent of the total time.

2. Refraction and Diffraction

The characteristics of waves developed in the various wave climates are for deepwater waves; that is, as the wave propogates through the water it is unaffected by the bottom. However, as the wave propogates from deep into shallow water, it will begin to "feel" the bottom (generally taken to be at a water depth equal to or less than half the wave length), refraction of the wave will occur. Refraction is where a variation in the velocity of a wave along its crest occurs as the wave crosses underwater contours at an angle, resulting in a proportional variation in wave length (the wave period remains constant) because the wave moves faster in the deeper water than it does in shallow. If the wave encounters an obstruction in its path, diffraction will occur around the end of that obstruction and reflection will occur along the face of it. As the shoreline at Vermilion is not significantly affected by wave reflection from the offshore breakwater or any other obstruction, it will be considered no further. Diffraction of water waves is the lateral transfer of energy along the wave crest and accounts for the wave activity in the lee of the obstruction.

At Vermilion, refraction occurs as waves are propogated from deep water conditions in Lake Erie towards the shoreline. Because of the irregular bottom contours of the bed, evaluation of the process is quite complex. Wave diffraction is present at Vermilion when waves encounter both the offshore breakwater and the two parallel piers that form the harbor entrance. When suitable wave conditions apply, the range of beach effe[illegible] by diffraction can cover all of Vermilion City Beach to the west and 1,200 to 1,400 feet east of the east pier, to the east.

To assess the degree of wave refraction occurring for waves driving on the Vermilion beaches, a Corps of Engineers computer program[13] was used. The purpose of the program was to solve the governing equations that describe the propogation of water waves and

to compute the characteristics of a wave ray passing from deep to shallow water. The program used a finite difference method to solve the differential equations. Input for the program was in two components. The first was to represent the bathymetry of the lake bottom and the physical features of the shoreline and shore structures at Vermilion. This took the form of a grid with depth from Low Water Datum (568.6 feet) to the bottom given at each point in the grid. Provision is made in the program to change the water level. The second component was the wave ray data. The starting location on the grid, initial propogating azimuth, wave height, wave period, and initial refraction coefficient (if the wave started on the grid in shallow water) were input. Output revealed the coordinates of the ray, the direction of propogation azimuth, depth of water, wave length, celerity, refraction coefficient, shoaling coefficient, and wave height along predetermined points on the ray up until the wave breaks on the shoreline.

For the Vermilion study it was necessary to bring the waves from deep water on Lake Erie into the immediate Vermilion area on a coarse grid (grid spacing 200 feet), and then to transfer the waves thus obtained onto a finer grid (grid spacing 100 feet), to obtain the detail in refraction required for the energy flux analysis. Waves were originated from the west, west-northwest, northwest, north-northwest, north, north-northeast, northeast, and east-northeast directions. A range of wave periods was chosen to cover the range expected on Lake Erie; thus, 3, 5, 7, 10, and 13 second waves were used. Selection of the starting coordinates for each wave ray was chosen so that the wave ray would terminate at a breaking point near the stations where littoral drift was to be analyzed. This made it necessary for waves with the same deepwater characteristics to be started at several locations.

The final product of the refraction analysis was values of the wave ray azimuth as it progressed shoreward for the range of possible wave originating directions and wave periods.

At the offshore breakwater and entrance piers, wave diffraction was achieved by applying methods outlined in CERC "Shore Protection Manual."[8] The diffracted wave height of the wave on the leeward side of the barrier was determined from the angle of wave ray approaching the barrier and the wave length. As the bottom shoaled from the structure to the shore, a combination of refraction and diffraction occurred in the lee of the breakwater. This affected the angle at which the wave ray approached the beach on breaking and was considered during energy flux calculations.

3. Breaking Height

The Corps' refraction program had a facility for computing the breaking height of a wave. This was achieved by using the following relations to compute the wave height along the ray.

$$H = Ho\ Ks\ Kr$$

where H = the height of the wave of any point.

Ho = deepwater wave height.

Ks = shoaling coefficient of the wave at the point.

Kr = refraction coefficient of the wave at the point.

The following relation was used to compute the wave height at breaking.

$$H_b = 0.8d$$

where H_b = breaking height of the wave.

d = depth of water through which wave passes at breaking.

At each point where the program performs its refraction calculations, it checks to see if the breaking criterion is satisfied.

As a considerable range of wave heights from the wave climates exist for each ray, a unit height deepwater wave was originated. The above criterion were then applied for each wave height by substituting the appropriate values.

4. Energy Flux Analysis

Calculations of the longshore energy flux were based on the following governing equation.

$$P = \frac{\rho g}{8} H_b^2 \ C_g \cos \alpha_b$$

where P = the resultant energy flux (lb ft sec^{-1} ft^{-1}).

ρ = density of water (1.94 slug ft^{-3}).

g = acceleration due to gravity (32.17 ft sec^{-2}).

H_b = breaking wave height (ft)

C_g = group wave celerity (ft sec^{-1}).

α_b = the angle between wave azimuth and normal to the shoreline tangent (degrees).

Resolving into components

$$P_{ls} = P \sin \alpha_b$$

$$= \frac{\rho g}{16} H_b^2 \ C_g \sin 2\alpha_b$$

$$P_{os} = P \cos \alpha_b$$

$$= \frac{\rho g}{8} H_b^2 \ C_g \cos^2 \alpha_b$$

where P_{ls} = longshore component of energy flux

P_{os} = onshore component of energy flux

CERC "Shore Protection Manual"[8] states that for shallow water, the group celerity of waves, C_g, approximates the wave celerity, C, and that this wave celerity can be given by:

$$C = \sqrt{gd}$$

where d = depth of water at wave breaking

It has been previously established that the breaking height of the wave approximates 0.8 times the depth at breaking, hence:

$$C_g = \sqrt{1.25 g H_b}$$

Substituting the values of C_g, ρ, and g into the equation for the longshore component of energy flux yields:

$$P_{ls} = 24.735 \ H_b^{2.5} \sin 2\alpha_b$$

The total longshore component of energy flux is finally computed by multiplying P_{ls} by the duration that waves of that unique period and height occur. Calculation of the energy fluxes are shown in the following example.

Consider the energy flux at Station 5 with a shoreline orientation of 118 degrees (azimuth of shoreline) and for waves originating from the northwest direction. From the data of TM-37,[10] the following wave climate applies (Table A2). The longshore energy flux computations for this northwest direction are shown in Table A3.

TABLE A2

WAVE CLIMATE FOR NORTHWEST WAVES
(Data Source TM-37 - 1948-1950)

	Wave Period (sec)			
Wave Height (ft)	1.5	2.5	3.5	4.5
0.75	58[1]	144	25	
1.5	19	150	150	
2.5		13	113	1
3.5		3	26	4
4.5			4	
5.5		2	12	

[1] Duration of waves in hours.

5. Calibration of Energy Flux to Longshore Transport

On any beach, the longshore transport of littoral material is governed by the equation:

$$Q = \frac{k\,P_{1s}}{(1 - p)(\rho s - \rho w)g}$$

where Q = the volume of longshore transport ($yd^3\ yr^{-1}$)

P_{1s} = longshore energy flux (lb-ft sec^{-1} ft^{-1})

p = porosity of sand in place (generally 0.4)

ρs = sediment density (generally 2.65 x 1.94 slug ft^{-3})

ρw = water density (generally 1.94 slug ft^{-3} for freshwater)

k = dimensionless constant

g = acceleration due to gravity (32.17 ft sec^{-2})

TABLE A3

CALCULATION OF LONGSHORE ENERGY FLUX (NORTHWEST DIRECTION)

H_o [1] (ft)	H_b [2] (ft)	T [3] (sec)	t [4] (hours)	Wave Ray Azimuth [5] (degrees)	α_b [6] (degrees)	P_{1s} [7] (lb-ft/ft-sec)	$P_{1s} \times t \times 10^6$ [8] (lb-ft/ft-3 yrs)
0.75	0.83	1.5	58	332	56	14.4	3.00
	1.03	2.5	144	342	46	26.6	13.97
	1.21	3.5	25	352	36	37.9	3.41
1.5	1.43	1.5	19	331	57	52.3	3.78
	1.80	2.5	150	340	48	106.9	57.74
	2.07	3.5	150	350	38	147.9	79.87
2.5	2.65	2.5	13	338	50	278.5	13.03
	3.05	3.5	113	344	44	40.6	163.37
	3.43	4.5	1	350	38	522.9	1.88
3.5	3.43	2.5	3	334	54	512.6	5.54
	3.96	3.5	26	338	50	760.2	71.15
	4.45	4.5	4	341	47	1,030.7	14.84
4.5	4.86	3.5	4	333	55	1,210.3	17.43
5.5	5.00	2.5	2	327	61	1,172.6	8.44
	5.67	3.5	12	330	58	1,701.9	73.52

Total longshore energy flux for 3 yrs = 530.6×10^6

Total longshore energy flux per second = 5.61[9] $\frac{\text{lb-ft}}{\text{ft-sec}}$

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[1] H_o = deepwater wave height.

[2] H_b = breaking wave height.

[3] T = wave period.

[4] t = duration (occurrence) of wave in three years.

[5] Wave ray azimuth is the angle measured clockwise from north of the wave ray at breaking.

[6] α_b = angle between wave ray azimuth and the normal to the shoreline tangent.

[7] Longshore energy flux per second released on the beach.

[8] Longshore energy flux per three years released on the beach = $P_{1s} \times t \times 3{,}600(\frac{sec}{hr})$

[9] The total for three years divided by the number of seconds in three years.

These constants are grouped together and termed β. Hence:

$$Q(yd^3\ yr^{-1}) = \beta\ P_{1s}(lb\text{-}ft\text{-}sec^{-1}\ ft^{-1})$$

Values proposed for β range from 7,500 for a general empirical relationship given by CERC[8] to 2,430 proposed by Jarrett[14] in his study of the North Carolina coast to a value of 883 proposed by CERC[8] for portions of the northeast coast. The general empirical relationship of CERC developed from laboratory and field observations in which characteristic sediment transport rates were actually measured. The studies were for open coastal regions where a semi-infinite supply of moveable beach material was available. At Vermilion, such boundary conditions are known not to exist as the beaches at Vermilion are partially protected and the amount of sand is limited. However, the relative distribution of the longshore energy flux is believed to be representative and proportional to the actual field conditions. Therefore, it was assumed that the same type of relationship as that given above exists at Vermilion and hence it was necessary to calibrate the longshore energy flux to the longshore transport; in effect, to determine a value of β for Vermilion.

The calibration, or correlation procedure involved the establishment of cells, or reaches, along the beach. These cells were established between each of the stations where the energy flux was computed, and between the entrance piers and the adjacent station where applicable. Hence, eight cells were established where the inflow-outflow conditions of beach material were known. The volume change of beach material within each cell was known from the volumetric analysis (see Section III) and for equilibrium to exist within the cell, the difference between the total material inflow and total material outflow must balance the volume change.

The components of inflow-outflow within the cells are onshore-offshore transport (assumed to be negligible at Vermilion), input by

bluff erosion (already considered in this analysis by longshore transport), dredging and replenishment (dredging only applicable for 1974 and 1975) and net longshore transport into the cell.

Hence, between any two stations at Vermilion, say A and B, the following balance applies for equilibrium to exist:

$$+\text{Volume Change}_{AB} = -\text{Dredged}_{AB} + \beta\, P_{1s_A} + \beta\, P_{1s_B}$$

where P_{1s_A} = the net longshore energy flux at station A.

P_{1s_B} = the net longshore energy flux at station B.

+ = a gain of material to the cell.

− = a loss of material to the cell.

With the volume change and material dredged determined for the cell and P_{1s_A}, P_{1s_B} computed, it is possible to determine the value of β for that cell. For Vermilion, the average value for β was found to be 1,940. Hence, the longshore transport, energy flux relation for Vermilion becomes:

$$Q(\text{yd}^3\ \text{yr}^{-1}) = 1{,}940\ P_{1s}(\text{lb-ft-sec}^{-1}\ \text{ft}^{-1})$$

6. Shoreline Equilibrium

To predict future change in beach orientation, the angle of equilibrium at the stations where longshore energy flux was computed was determined. This analysis considered the beach shoreline to be in equilibrium when the total net longshore energy flux at a station and equal to zero. Such a condition occurs when the resultant of the longshore energy flux and onshore energy flux was perpendicular in vector direction to the tangent of the shoreline at that point.

For the analysis, the total resultant (the vector sum of the individual resultants for all waves breaking at the station) was computed and the azimuth of this resultant determined. The perpendicular to this azimuth is the angle of shoreline equilibrium.

EXHIBIT C.2

SAND PUMPING DEMONSTRATION PROGRAM

VERMILION HARBOR, OH
SAND PUMPING DEMONSTRATION
MAY 1979

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<u>Main Report</u>

U.S. Army Engineer District, Buffalo
1776 Niagara Street
Buffalo, NY 14207

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ACKNOWLEDGMENTS

This report has been written on the basis of information from participants of the Sand Pumping Demonstration at Vermilion Harbor, OH. Significant contributors include:

Buffalo, NY, Army Corps of Engineers

Michael Wojnas - Project Manager, Western Basin
Peter Bader - Civil Engineer Trainee

Cleveland, OH, Army Corps of Engineers, Projects Office

John Matricardi - Projects Engineer
Rocky Johnston - Chief Inspector/Construction Representative
Dan Richart - Inspector/Laborer
Jim Entsminger - Laborer
Art Gillmore - Mud Cat Operator of Marine Services Branch
James Savett - Power Boat Operator

Finally, the efforts of other individuals who participated in the demonstration project or report production, reproduction, and distribution; but whose names were not mentioned, are gratefully acknowleged.

PART I - GENERAL

Introduction and Purpose

1. This is a report on the artificial sand transport field demonstration that the U. S. Army Engineer District, Buffalo, performed during the month of May 1979 in Vermilion, OH. There were two objectives of this demonstration program. The first was to determine if the artificial transport of sand would be a viable alternative for mitigation as suggested in the Vermilion Harbor, OH, Preliminary Section 111 Report (Note Alternative 2 of the Preliminary Section 111 Report Syllabus, Inclosure 1), dated May 1978. The second was to determine if utilization of a hydraulic dredge produced and distributed by "Mud Cat" Division, National Car Rental Services, Inc., or similar equipment, could feasibly dredge and transport sand at Vermilion, OH, and other Federal recreational harbors.

2. This demonstration project took place in Vermilion, OH, which is located on the south shore of Lake Erie, at the mouth of the Vermilion River, approximately 37 miles west of Cleveland, OH (Plate 1). The major harbor elements, shown on Plate 1, include east and west approach channels leading from the lake, the lower 3,600 feet of the Vermilion River, and four artificial lagoons. Channel protection is provided by parallel piers and a detached offshore breakwater (Photo No. 1, Appendix A).

Project History and Public Involvement

3. The Vermilion Harbor project is a Federally constructed harbor for recreational and commercial fishing craft. The latest Federal improvements to the harbor were completed in December 1973, and consisted of channel widening and deepening and construction of the 864-foot detached breakwater approximately 300 feet offshore. Subsequent to this latest construction, there have been repeated complaints that the breakwater is causing significant shoreline changes and serious environmental, health, flooding, and recreational problems in the adjoining updrift area. By letters dated 31 July 1974 and 13 December 1974, William B. Nye, former Director of Ohio Department of Natural Resources, officially requested that the Corps investigate the severity of the erosion problem (shoreline changes) created by the detached breakwater under the authority of Section 111 of Public Law 90-483. The partially completed investigations concerning the other impacts are presented in a separate report entitled "Study of the Impacts of the Offshore Breakwater...", 1 April 1978.

4. The Buffalo District initiated a preliminary study of the alleged erosion problem in 1975. Stage 1 of the Section 111 study specifically addressed the effect of the Vermilion Harbor navigation works on the shoreline processes. In the Buffalo District's "Preliminary Report on Section 111 Study of Vermilion Harbor, OH, dated 21 January 1976, it was recommended that no action be taken at that time to prevent or mitigate shore damages since it could not be determined whether the recent shoreline change was caused by high lake levels or the detached breakwater; and a 5-year beach monitoring program be accomplished prior to initiation of further detailed studies. Subsequent to completion of the Preliminary Report, further

evaluation led to the conclusion that the 5-year monitoring program would only identify short-term shoreline changes and because of very little baseline (prebreakwater construction) data, any conclusions drawn from the monitoring program would not be highly reliable. For these reasons, the Buffalo District monitoring program was terminated and in early 1977, it was recommended that there be a detailed study performed under the Section 111 authority.

5. A preliminary (Stage 2) Section 111 Report was completed in August 1978. This report concluded that the Federally constructed breakwater at Vermilion had caused a reorientation in the shoreline east of the harbor (Plate 2). This reorientation resulted in accretion of the beach at Lagoons Beach (see Photo No. 1, Appendix A), and loss of beach at Linwood Beach (see Photo No. 2, Appendix A). A series of preliminary alternatives to mitigate the loss of beach at Linwood were evaluated, including the artificial transport of sand from Lagoons Beach to Linwood Beach.

6. On 31 August 1978, the Corps held a public meeting in Vermilion to present to the people of Vermilion a range of possible alternatives for mitigating shoreline damages under the Section 111 authority and to obtain the views of officials and the general public concerning these alternatives. Inclosure 1 is a copy of the information packet for that meeting. A second meeting was held in Vermilion on 11 October 1978 with the Mayor of Vermilion, City Council members, representatives of local private organizations, and ODNR to discuss Section 14 and 111 Studies (Inclosure 2). Subsequent to the 11 October 1978 meeting, the Buffalo District concluded the only viable alternatives for mitigation under Section 111 would be: (a) artificial transport of sand from Lagoons Beach to Linwood Beach (Alternative 2); and (b) beach replenishment from an external source (Alternative 4). The Buffalo District also concluded that an artificial sand pumping field demonstration be undertaken in the spring of 1979 to determine the feasibility of this alternative.

7. Initial contacts by telephone were made with Mr. Calvin C. Blackman and Mr. James McClimans, Vermilion Lagoons, Inc., Trustees, in October and November 1978 to inform them of our proposed demonstration project and to seek approval to perform this demonstration. By letter dated 5 December 1978 (Inclosure 3), a brief description of the demonstration project was forwarded to Mr. Blackman at his request. As stated in this letter, the Buffalo District originally planned to utilize a truck-mounted sand pump, operated by the Detroit District. However, in January 1979, after consulting with the Detroit District and concluding that their sand pump would not be available, the Buffalo District then decided to use the "Mud Cat" for this demonstration.

8. Approval from the Vermilion Lagoons, Inc. (owners of Lagoons Beach) was granted by letter dated 15 March 1979 (Inclosure 4), with the limitation that the project be completed before 21 May 1979. With this approval, the Buffalo District prepared a Section 404 Public Notice and Environmental Assessment (EA) and distributed it to the public on 26 March 1979, outlining the demonstration project as shown on the plates in Inclosures 5 and 6. The Buffalo District held a Public Hearing concerning the EA and Section 404 on

10 April 1979 (Inclosure 7) in Vermilion and determined that there was no local opposition to this demonstration project. By letter dated 25 April 1979, the State of Ohio Environmental Protection Agency granted a Section 401 Water Quality Certificate (Inclosure 8), thereby completing the necessary requirements to perform the demonstration.

Demonstration Contracts and Funding

9. Funding for the Demonstration Project was requested under O&M Regular Appropriations and granted in early February 1979. Sixty thousand dollars of O&M funds were budgeted within the existing Vermilion Harbor Operations & Maintenance program for the operation and monitoring of the demonstration. An "Invitation for Bid" (IFB) for the equipment rental was issued 2 April 1979 (Inclosure 9), and bids were opened on 19 April 1979. The Buffalo District awarded the various contracts, obtained required leases for rights of entry, and scheduled the project to begin 30 April 1979.

PART II - DEMONSTRATION PROGRAM OUTLINE

Project Plan

10. As originally planned, this project entailed the dredging of approximately 15,000 cubic yards of sand from Area A at Lagoons Beach (Photos No. 2, 3, and 4), and depositing it along the Linwood Beach (Photo No. 5) at Area B, as shown on Plate 3. The amount was selected for the following reasons: (a) an estimated 15,000 cubic yards of sand deposited at Linwood Beach would provide the Linwood Park residents a suitable beach for the summer while having a minimal adverse impact upon the Lagoons Beach; and (b) due to the initially perceived time constraints (approximately 1 month to perform the work), no more than 15,000 cubic yards could be pumped, even with excellent working conditions, and that this amount would be a sufficient amount of sand to monitor its movement downdrift back to Lagoons Beach.

11. The preliminary layout of the borrow area (Plate 3) was based on surveys taken in August 1977, October 1977, and August 1978 (Inclosures 11, 12, and 13). Sand was to be pumped from the primary borrow source in the lake adjacent to the east pier at Lagoons Beach to Area B at Linwood Beach. Also, sand from Lagoons Beach was to be pushed by conventional earthmoving equipment into the primary borrow area to minimize shoreline recession at Lagoons Beach. Earthmoving equipment would also be used to spread the pumped sand along Linwood Beach to create a natural beach appearance.

Survey and Sediment Data

12. Prior to the actual demonstration operation, the Corps of Engineers made an additional survey (Inclosure 14), and sampled the bottom materials (Inclosure 10), in the vicinity of the proposed borrow source. This was to insure that the material to be pumped would be acceptable for beach replenishment and of sufficient volume to make the demonstration worthwhile. The bottom sampling, on 10 and 11 April 1979, indicated that there was much less suitable sand in the proposed borrow area than anticipated. Relatively clean, fine sand extends only 100 to 150 feet offshore along the east pier and gets progressively narrower easterly of the pier. The northeasterly third of the proposed primary borrow source is predominately silts and clays and not a suitable source for beach replenishment. On the basis of this information, the final limits of the primary and secondary borrow areas were established as shown on Plate 4.

Project Monitoring Program

13. The District established the following monitoring program in order to evaluate the efficiency and effectiveness (production wise) of the demonstration project and the feasibility of future sand pumping projects. Soundings were taken three times during the spring and summer of 1979 to determine the amount of material removed from Area A (Lagoons Beach) and pumped to Area B (Linwood Beach) and to determine the rate at which the sand would return to Area A (Lagoons Beach).

14. A Predemonstration survey was done in April 1979 (Inclosure 14) and a post-demonstration survey in June 1979 (Inclosure 15) to determine the quantity of sand deposited on Linwood Beach. (See paragraph 25.) A third survey was done in August 1979 to help evaluate recirculation of sand back to the borrow area (Inclosure 16).

PART III - DEMONSTRATION PROJECT

Equipment

15. The District Office rented two pieces of earthmoving equipment and a Mud Cat to perform this demonstration project. A John Deere 450-C dozer was delivered to the site on 4 May 1979 to work in either Area A pushing sand into the primary borrow area and for grading the beach; or at Area B, building out the beach at the fill site. A John Deere 644-B 3-cubic yard front-end loader was delivered to the site on 2 May 1979 to help lay out discharge pipe along the beach (see Photos No. 9 and 10, Appendix A), and work in Areas A or B as required.

16. The Mud Cat accessory equipment package AEP-1F (Inclosure 9, attachment 1), was delivered directly from the factory by enclosed tractor-trailer and arrived on site on 30 April 1979. This package included the discharge pipe and accessories. The Mud Cat (see items AEP-1F1, 2, 4, and 6 of Inclosure 9, attachment 1) was delivered to the site on 5 May 1979 by flatbed trailer. The District rented the boat lift at the Vermilion Power Boat, Inc. marina to lift and place the dredge in the water (see Photos No. 6 and 7). A tender from Dredge LYMAN was used to position the Mud Cat at the borrow site.

17. A Mud Cat is a self-contained, floatable hydraulic pipeline dredge. Forward and backward movement is provided by a deck-mounted winch and is capable of providing a 9-foot wide cut to a depth of 15 feet (Photos No. 18 and 19). The Mud Cat equipment was used to hydraulically dredge and pump sand from Lagoons primary borrow source to Linwood Beach. To accomplish this, approximately 2,500 feet of discharge line was assembled.

Preparation and Setup

18. During the first 10 days (30 April to 9 May 1979) at the site, field personnel removed debris and pushed sand into the primary borrow area at Lagoons Beach (Photo No. 8) and set up the 8- and 6-inch discharge pipes for the dredging operation. Debris cleanup was done to remove debris which could damage the Mud Cat. Debris cleared consisted primarily of wood material ranging in size from 25 feet long and 30 inches in diameter to smaller branches and miscellaneous washup material. The debris was temporarily stored and eventually trucked away to a local upland disposal site by the Lagoons Beach Association.

19. Four 20-foot sections of 8-inch diameter steel flanged discharge pipe were assembled at the stockpile at Lagoons Beach House (Photos No. 9, 12, and 13). Once a section was done, it was dragged to the shoreline for final assembly to another 80-foot section with the front-end loader. Just prior to placing the 80-foot sections in the water, two floatation pipes were attached to each of the 20-foot steel pipes with three equally spaced steel bands. These 4-inch diameter plastic float pipes, each 20 feet long, were capped at each end to prevent the 8-inch discharge line from sinking (Photo No. 14).

20. Several of these 8-inch pipe assemblies were connected together by 6-foot lengths of rubber flex pipe to compensate for movement of the dredge as it made each cut (Photo No. 15). This process continued until approximately 200 feet of 8-inch pipe was in place.

21. The remainder of the discharge line, approximately 2,300 feet, was made up of 8-inch diameter plastic pipe extending to Linwood Beach. Each 19-foot section of the pipe was connected by a bell and spigot with a snap lock ring band and was left on the beach during dredging operations. The front-end loader was used to transport six pieces of pipe at one time towards Linwood Beach (Photos No. 10 and 11). This process continued until the required length of pipe was in place. Once in the place, the Mud Cat was positioned at the primary borrow source area and on 10 May 1979, the pumping was ready to begin.

Anchor System and Operation

22. Once the Mud Cat dredge was in position within the primary borrow area, the cables from the self-contained winching system were anchored to the light standard on east pier serving as a fixed pivot point; and a 5-ton stone from the east pier positioned on the beach to serve as a land anchor (Photos No. 16 and 17). The dredge was positioned at the light standard as a starting point and would pull itself toward the land anchor. Once a cut was completed, a laborer would slacken the cable, then the dozer would reposition the land anchor and then tighten up the cables for the next cut (Photos No. 18 and 19). Limits of the borrow area were 100 to 150 feet offshore of the shoreline with a width tapering east away from the jetty (Plate 4). However, after the first couple of days, it became apparent that underwater debris, i.e., trees, rocks, and other unsuitable material, would plug and snarl the cutting head of the Mud Cat. Thus, the Mud Cat had to be repositioned to pump sand from the secondary borrow source area at the shoreline where the presence of debris could be observed and corrected before dredging.

23. At the discharge end (Linwood Beach), three 20-foot sections of pipe with perferations approximately 1-1/2 inches in diameter were attached to the 6-inch diameter pipe line so that the sand discharged would fan out along a wider reach, rather than depositing sand in one centralized area (Photos No. 20, 21, 22 and 23). Evidence of sand buildup is seen at the concrete block located on the shoreline (Photo No. 15, noted with an arrow). The block shown in Photo No. 23 appears to be out of the water, thus indicating sand buildup on the beach. After the first day of pumping, the perforated pipes were disconnected and an open-end pipe discharge was used for the remainder of the job, because gravel tended to clog the perforations.

Labor Force

24. The labor force involved in performing the demonstration was as follows:

Number	Classification	Tasks
1	Superintendent	- overall supervision

Number	Classification	Tasks
2	Laborers	- setting up equipment - repairs to pipeline - cleanup - etc.
4	Operators	- Mud Cat, earthmoving equipment, and launch

Also present part time:

1	Laborer	- setting up equipment
2	Representatives from Mud Cat	- helped in setting up Mud Cat and provided instruction in operating

Sand Pumping Performance

25. Pumping operations continued up to and including 19 May 1979, totaling 9 days. Disassembly of pipes and cleanup operation continued until 23 May 1979. Field estimates show that approximately 3,200 cubic yards of sand were pumped. A more detailed calculation of 2,500 cubic yards was obtained by comparing plotted sounding elevations of pre- and post-demonstration sounding surveys.

PART IV - EVALUATION OF THE VERMILION SAND PUMPING DEMONSTRATION PROGRAM

26. Considerable knowledge was gained with respect to artificially transferring sand with the use of hydraulic dredging equipment. Delays were encountered because of late delivery of the Mud Cat on 5 May 1979, and Mud Cat representatives did not arrive until 8 May 1979. This prevented dredging operations from beginning immediately. An additional day was spent in setting up the Mud Cat and receiving instructions on operating the Mud Cat. On 10 May 1979, dredging and pumping operations commenced. These operations ceased on 19 May 1979 in order to comply with the 21 May 1979 completion date specified by Vermilion Lagoons, Inc., providing only 9 days of pumping.

Comparison of Performance and Costs with Goals

27. As stated in paragraph 10, the goal of this demonstration program was to pump approximately 15,000 cubic yards of beach material from the area of accretion at Lagoons Beach updrift to the area of erosion at Linwood Beach, a total distance of about 2,800 feet to 3,000 feet. Estimated unit cost for obtaining the 15,000 cubic yard goal was $4.00 per cubic yard. In establishing this goal, it was assumed that approximately 1 month (say 20 workdays) would be provided for the actual pumping of sand from source to area of deposition. In actuality, a total of only 2,500 cubic yards of beach material were pumped during 9 days of pumping operations.

28. Based on before- and after-project surveys, it is estimated that approximately 2,500 cubic yards of beach material was pumped from Lagoons to Linwood Beach, or about 17 percent of the goal of 15,000 cubic yards. The actual total cost of the demonstration program was $41,000, producing a unit cost of $16.40 per cubic yard. Circumstances that contributed to the poor performance and high unit cost of the demonstration program include:

a. About a 1-week delay in obtaining necessary rights of entry and temporary easements.

b. Longer than expected time to complete contracting procedures.

c. Few days delay in shipping Mud Cat equipment because of Teamsters' strike.

d. More time required to mobilize than estimated.

e. Inefficiency in sand pumping production because of long pumping distance for relatively large size of beach material pumped.

f. Lost production time due to rough seas and minor repairs during the demonstration.

As discussed below, improvements in some of these problem areas would undoubtedly improve the performance significantly.

Suggested Modification of the Demonstration Program to Improve Performance

29. With some modification to the procedure and equipment, the Mud Cat dredging operation could be made more efficient. A screening mechanism could be used to prevent debris from entering the impellers and cutting heads and clogging the Mud Cat and pipeline to cause loss of production time. During the demonstration, a tire and wheel were lodged in the cutter head and had to be hacksawed out.

30. A 6-foot section of rubber flex pipe separated at the steel flange joints (see Photo No. 15). To correct this, holes were drilled through the rubber flex pipe and steel flanges, then the flanges were bolted. This modification was performed in the field and required a considerable amount of time. If this were done at the factory prior to delivery, the production time lost in the field because of this problem could have been eliminated.

31. The distance the Mud Cat had to pump material was too great for the type of material pumped. For medium sand with gravel which was encountered at the project site, the maximum feasible pumping distance would be about 1,500 feet. For silts, 3,000 feet would probably be the maximum distance. Since medium sand with gravel was pumped approximately 3,000 feet under a 10-foot head, the pump could not deliver sand with sufficient velocity at the discharge end. This caused the sand to settle in the pipe, accumulate, and after a short period of time, restrict flow completely. To correct this, a 15-minute dredge, 15-minute pump clear water cycle was used, cutting production time in half. A booster pump situated approximately half-way along the discharge pipe would increase sand velocities and thereby increase production. This would be extremely important if time is the controlling factor, as it was in the demonstration.

32. It took considerable manpower to unload, assemble, disassemble, and reload the pipe. Additional laborers in conjunction with better means of transporting the pipe to assembly points are recommended.

33. Additional equipment needed that was not procured for the demonstration:

a. Some form of shelter in case of a sudden change of weather, especially at the Linwood Beach area.

b. Sanitary facilities on or near site.

c. Small truck or pickup to carry miscellaneous equipment and carry out various duties. The one power wagon procured was defective and generally useless.

d. Set of tools either owned by COE or the Contractor.

Comparison of Costs

34. Estimated vs. Actual Costs for the Demonstration Program. Prior to initiating the demonstration program, a detailed estimate of equipment rental and manpower costs was prepared. Based on rental of the equipment for 28 days, which would have provided for 20 days of actual pumping, it was estimated that the total cost would be $60,000, or $4.00/cubic yard for the 15,000 cubic yards to be moved (see Figure 1, following). However, for reasons previously discussed, only about 2,500 cubic yards of sand was pumped to Linwood Beach during the demonstration. The total cost of the demonstration program was $41,000 (including all equipment rental and labor costs), or approximately $16.40/cubic yard for the 2,500 cubic yards pumped.

35. It is expected that in any given year, 20 days of pumping could be obtained before Memorial Day weekend. With a booster pump midway between Lagoons and Linwood Beaches, actual production rates could be increased considerably over the rate obtained during the demonstration project. Assuming the pumping rate with the booster pump would be 80 cubic yards/hour, a 10-hour day, and 5 days down-time for adverse weather, the total production for 15 days of actual pumping would be approximately 12,000 cubic yards of beach material pumped. Labor and equipment rental costs for this program would be approximately $60,000, producing a unit cost of about $5.00/cubic yard of material pumped.

Alternate Method by On-Beach Trucking

36. For cost comparison purposes, an alternate method of operation was evaluated. The alternative was not actually implemented as was the pumping demonstration project (see Inclosures 17).

37. The alternative provides for on-beach trucking to transport sand in lieu of placing 2,500 to 3,000 lineal feet of pipe and using the Mud Cat dredge to pump sand through the pipe.

38. Assumed for use were: three trucks, 12 cubic yards each, one 10-ton crawler crane with a 1 cubic yard dragline bucket, and one 2-3/4 cubic yard crawler loader, and respective operators, oilers, and laborers.

Comparison of Pumping by Hydraulic Dredge (Mud Cat) to On-Beach Trucking

39. Two estimates for transporting sand by on-beach trucking were prepared. One estimate was for the 2,500 cubic yards that was actually realized from the sand pumping demonstration, and another was for 15,000 cubic yards which was the goal for the demonstration project.

40. Based upon an estimated production rate of 104 cubic yards/hour for a 1 cubic yard dragline (see Inclosure No. 17), it would require approximately three 10-hour workdays to transport 2,500 cubic yards at an estimated cost of $14,600 or about $5.84/cubic yard. Using the same production rate, it would require approximately fifteen 10-hour workdays at an estimated cost of $64,400 or about $4.30/cubic yard to transport 15,000 cubic yards (see Figure 1).

41. Rough lake conditions and other problems, discussed above, delayed Mud Cat operations considerably, to the extent that actual pumping took 8 days or more than twice the amount of time that was estimated for on-beach trucking. However, experience gained from the demonstration and reasonable improvements could increase pumping productivity to a level more competitive with that of on-beach trucking.

PART V - CONCLUSION

42. Based on a comparison of the desired (15,000 cubic yards) vs. the actual (2,500 cubic yards) amount of beach material pumped from Lagoons Beach (Area A) to Linwood Beach (Area B), it is concluded that the Sand Pumping Demonstration Program at Vermilion Harbor was unsuccessful. However, as discussed in Part IV, several problems encountered prior to and during the actual operation which significantly constrained production might well be resolved by reasonable improvements in premobilization planning and in the pumping operation. Nevertheless, because of the large size of material to be pumped and the susceptibility of Mud Cat operations to even slightly bad weather, the probability of improving production over that achieved during the demonstration project is uncertain. Accordingly, the economic efficiency of sand pumping is uncertain.

43. For reasons cited above, use of an hydraulic dredge, such as the Mud Cat used in the demonstration project, to pump sand to mitigate shore damage at Vermilion Harbor is considered to be far less desirable than use of a dragline and on-beach trucking.

APPENDIX A

CONTENTS

APPENDIX A

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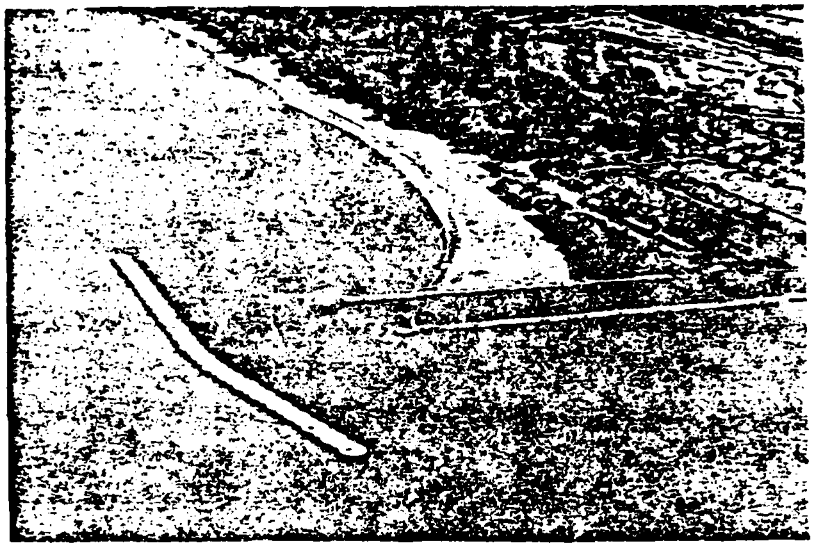
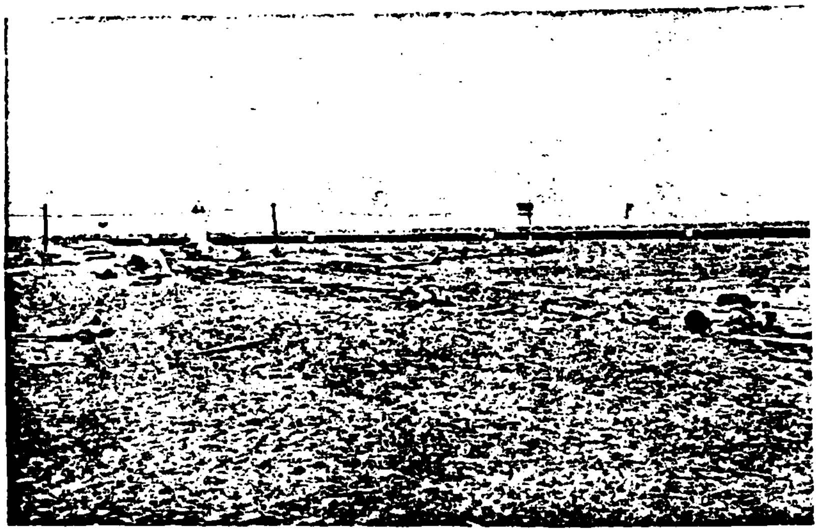
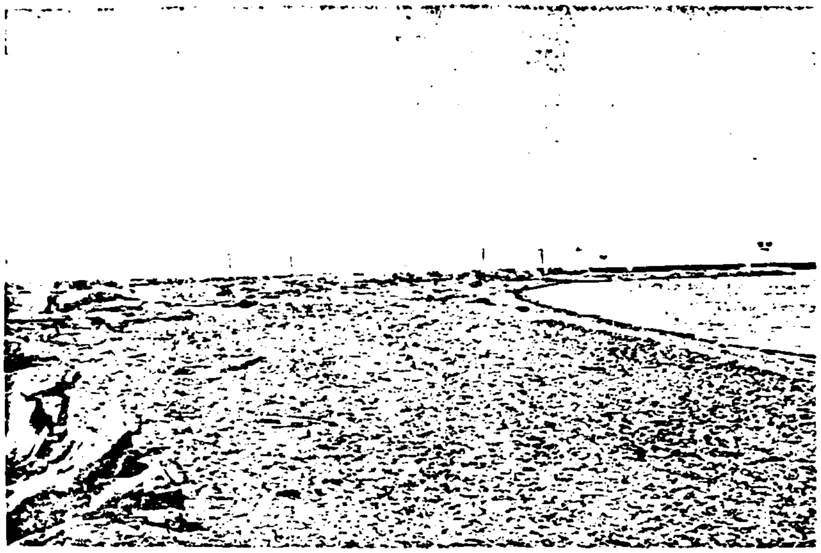


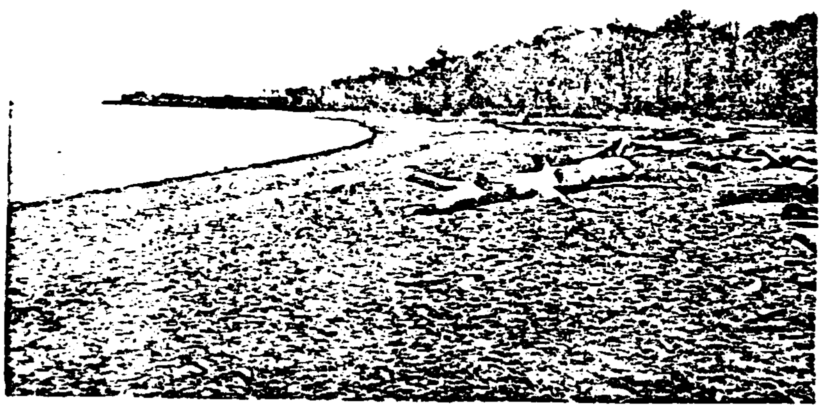
No. 1 - Aerial photo showing mouth of Vermilion River and Lagoons Beach before sand pumping demonstration



No. 2 - Lagoons Beach before sand pumping demonstration looking offshore towards east and west piers, respectively, and the detached breakwater

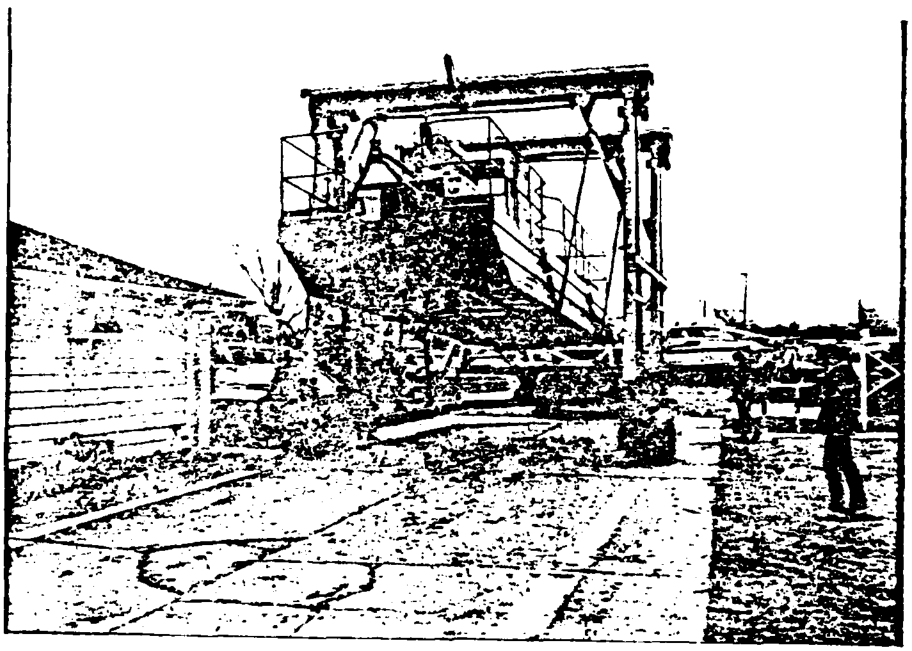


No. 3 - Lagoons Beach before sand pumping demonstration;
same view as Photo No. 2 but further away from piers

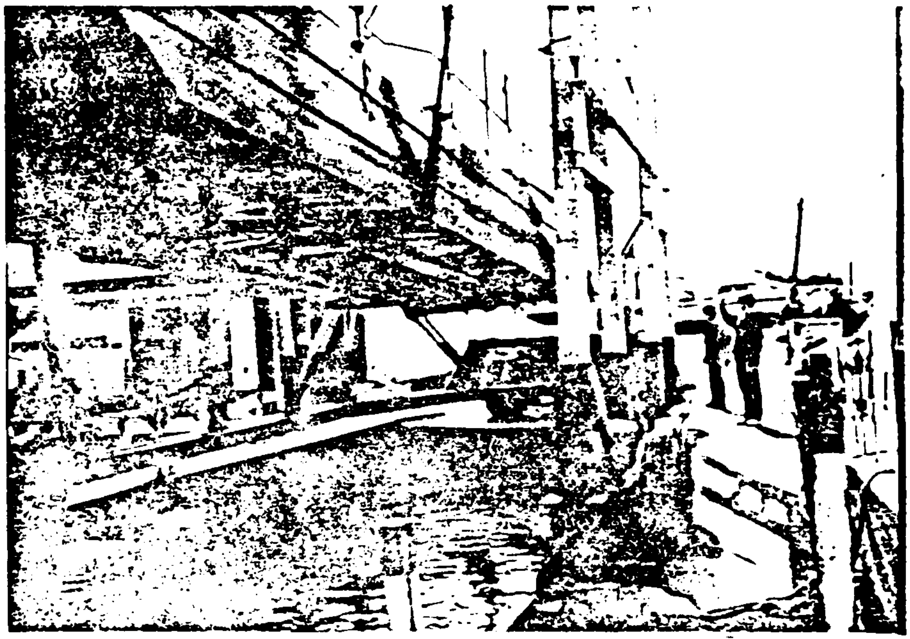


No. 4 - Lagoons Beach before sand pumping demonstration
looking away from piers towards Linwood Beach
which is in the far background

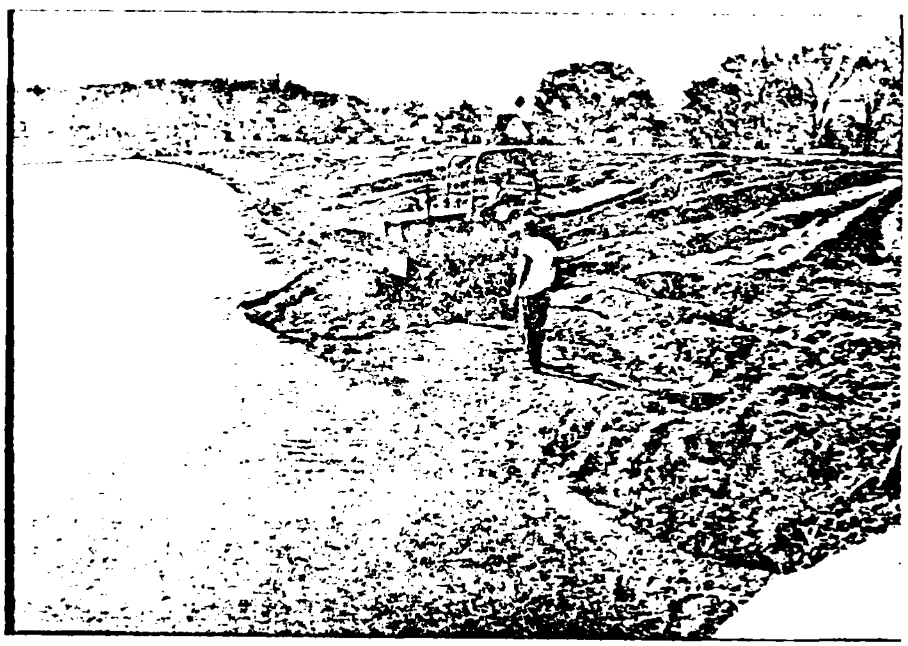
No. 5 - Linwood Beach before sand pumping demonstration



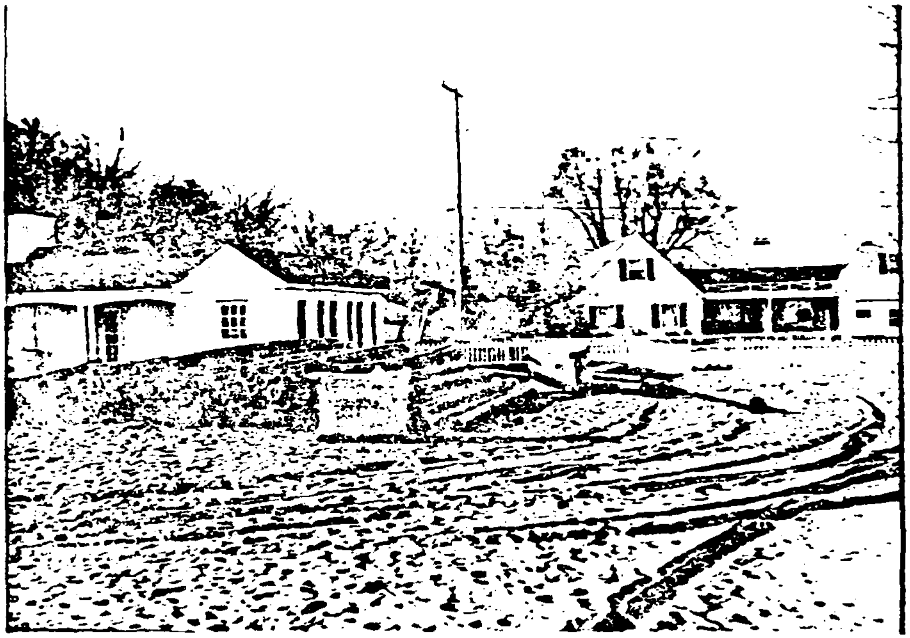
No. 6 - Removing Mud Cat off flatbed trailer with boat crane, 5 May 1979



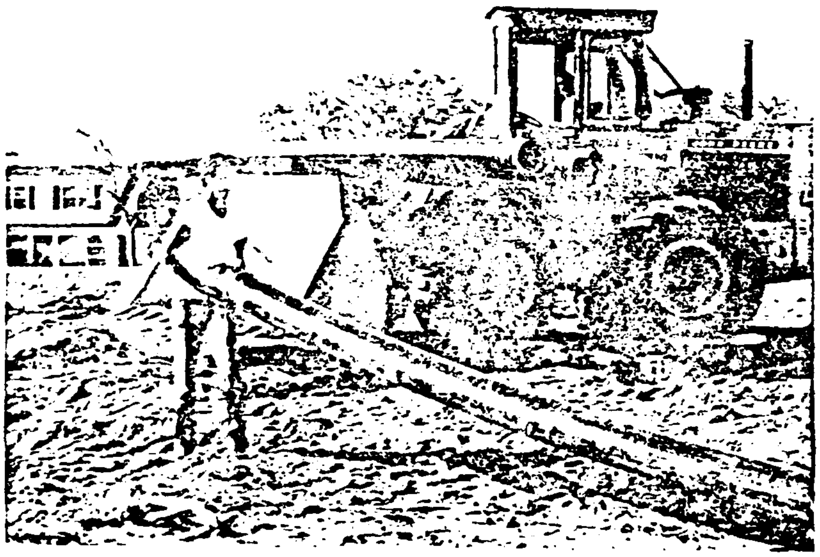
No. 7 - Lowering Mud Cat into water, 5 May 1979 at Vermilion Power Boats, Inc. Marina



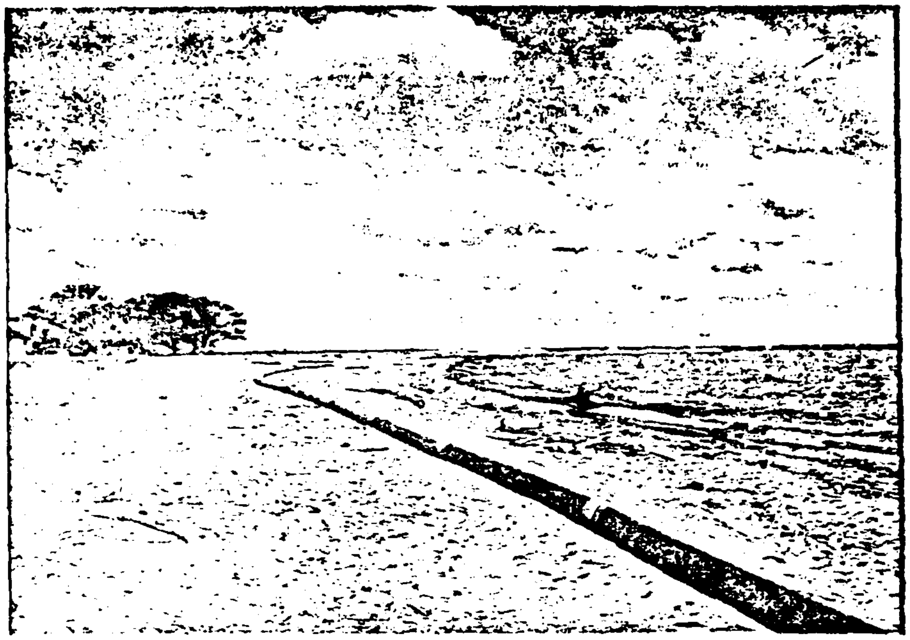
No. 8 - Dozer grading and pushing sand at secondary borrow area in towards primary borrow area at Lagoons Beach



No. 9 - Six-inch diameter plastic and 8-inch steel flanged pipes stockpiled at Lagoons Beach House

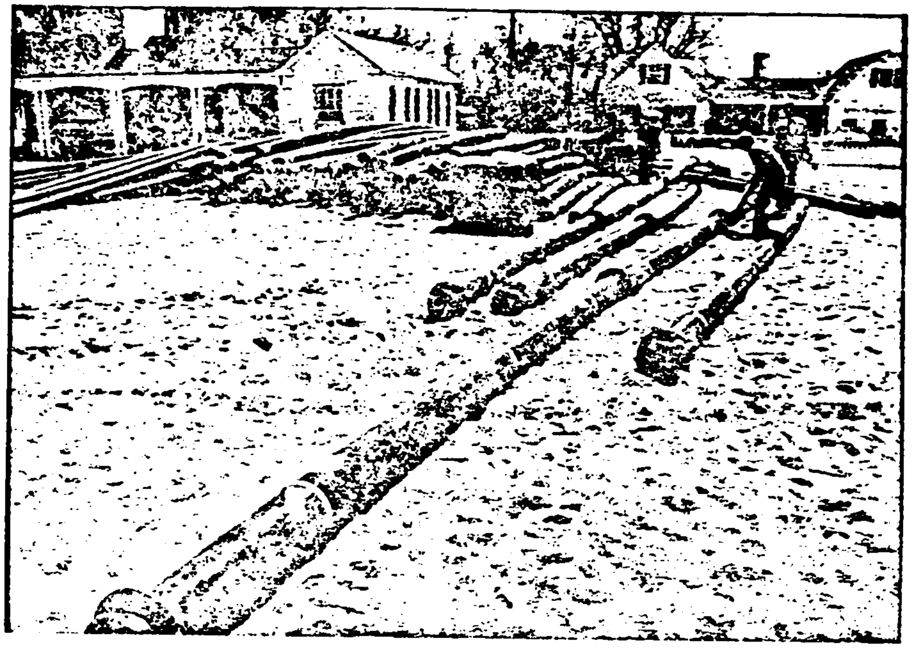


No. 10 - Transporting 6-inch diameter pipe to beach area for assembly

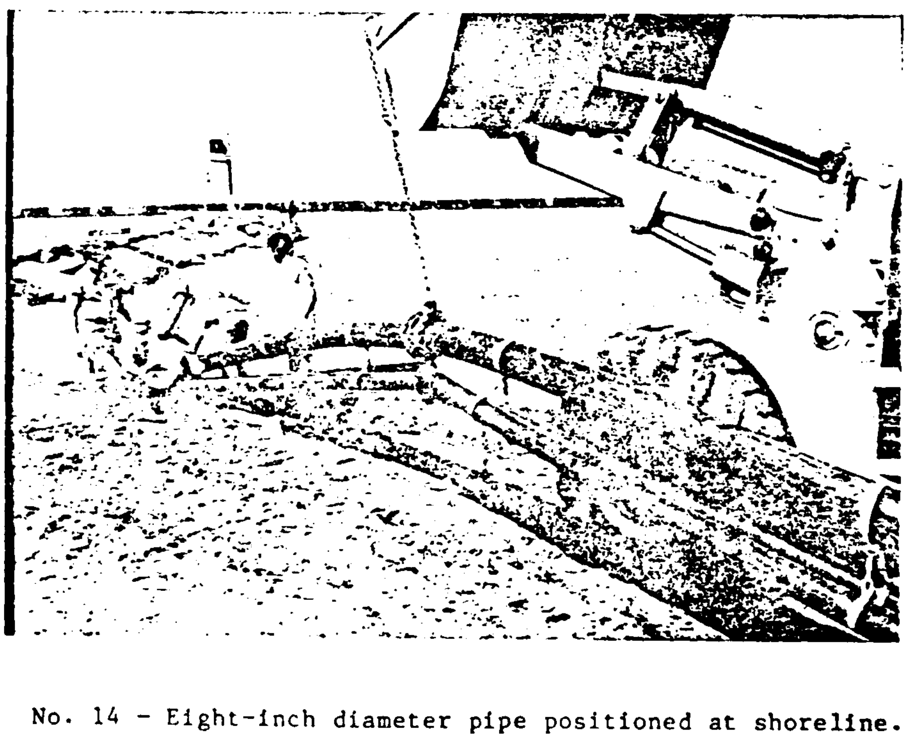


No. 11 - Assembled 6-inch diameter plastic sand transport pipe

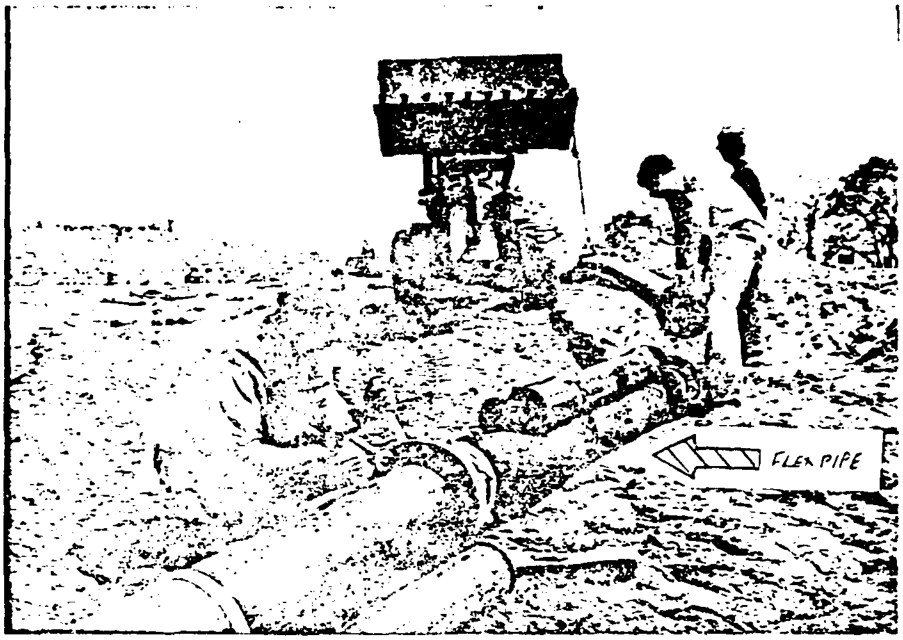
No. 12 - Eight-inch diameter steel flanged pipe



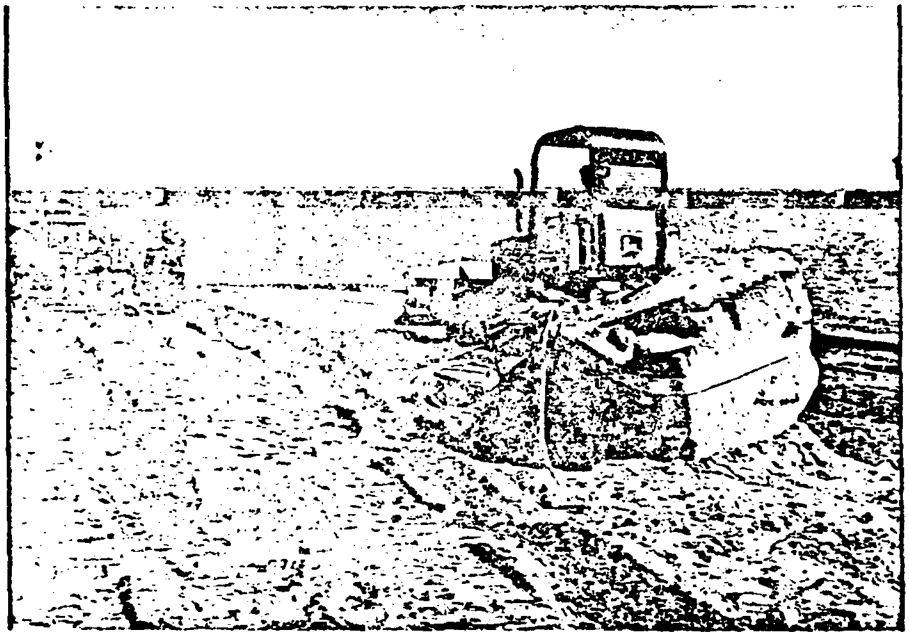
No. 13 - Four 20-foot sections of 8-inch diameter pipe assembled at Lagoons Beach House, then dragged to position near shoreline for final assembly



No. 14 - Eight-inch diameter pipe positioned at shoreline. Smaller pipes w/capped ends are float pipes attached by three clamps

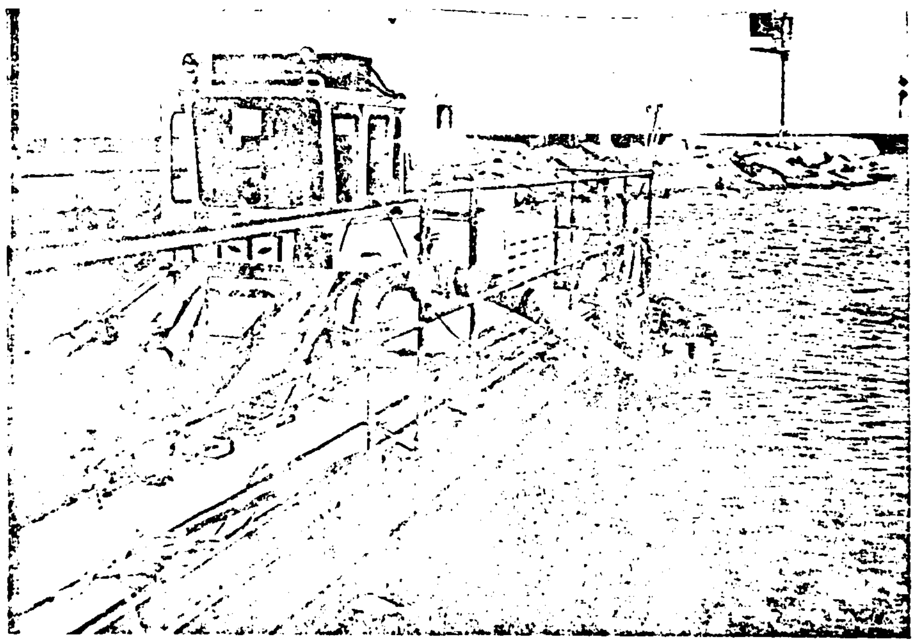


No. 15 - Six-foot section of rubber flex pipe

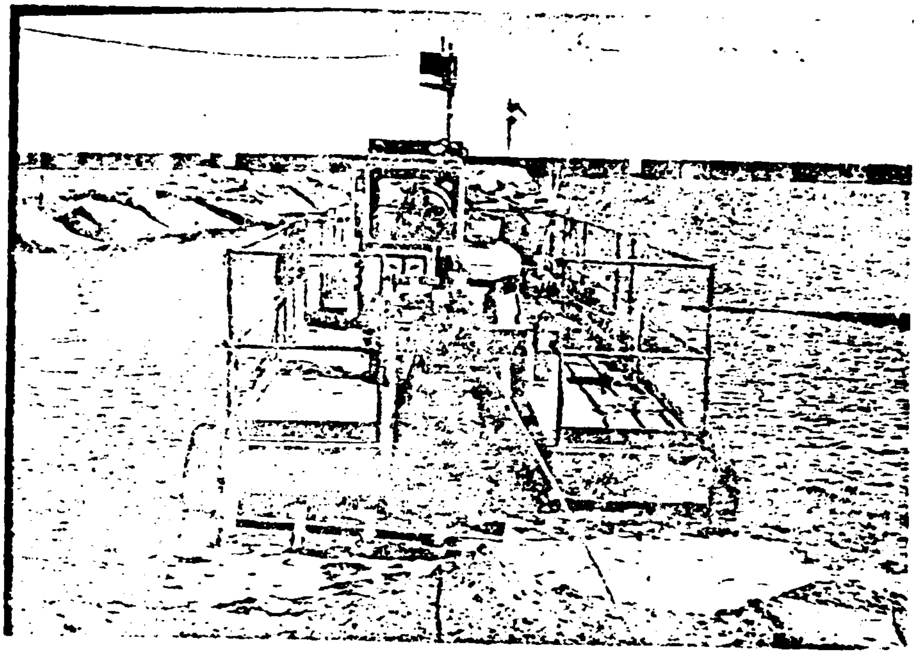


No. 16 - Land anchor and cable system for maneuvering Mud Cat in towards the shore during dredging operations

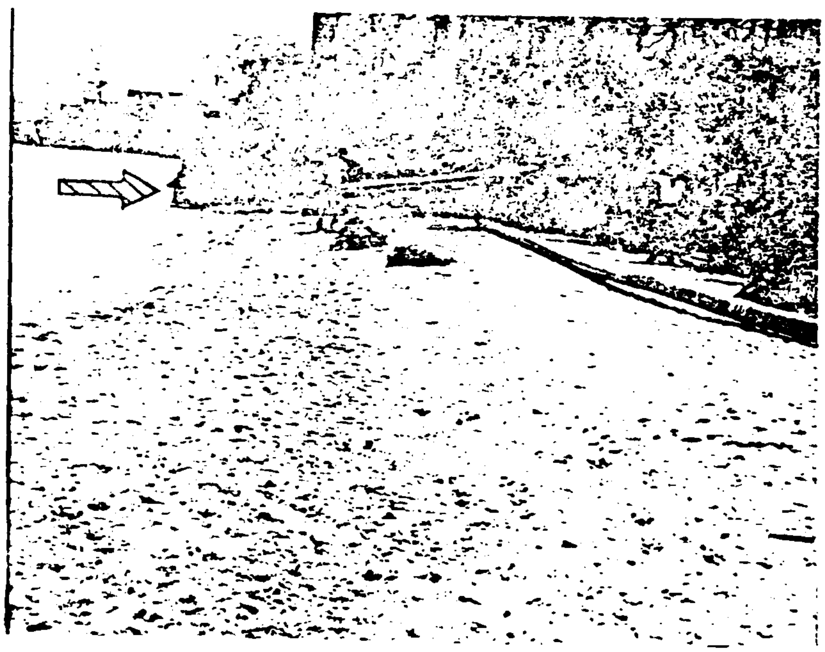
No. 17 - Aerial photo of Mud Cat operation, transport pipe stone anchor system, and wedge slope dredging pattern



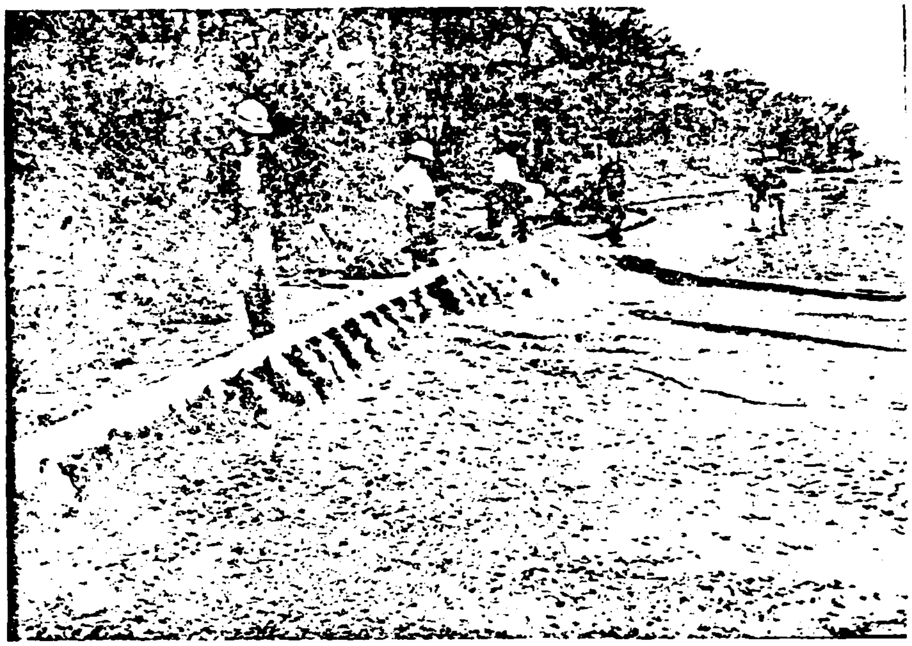
No. 18 - Mud Cat Model 915 in operation



No. 19 - Mud Cat in operation illustrating cable winch system



No. 20 - Perforated pipe at discharge end during assembly. Note concrete structure in water. Linwood Beach.



No. 21 - Sand transport in operation at discharge area, Linwood Beach

No. 22 - Sand transport in process.

No. 23 - Sand built up at Linwood Beach. Note sand buildup at concrete structure

EXHIBIT C.3

SECTION 14
LETTER REPORT

DEPARTMENT OF THE ARMY
BUFFALO DISTRICT, CORPS OF ENGINEERS
1776 NIAGARA STREET
BUFFALO, NEW YORK 14207

NCBED-PF

30 September 1977

SUBJECT: Section 14 Reconnaissance Report for Elberta Beach and Linwood Park, Vermilion, OH

Division Engineer, North Central
ATTN: NCDPD

AUTHORITY

1. This report was prepared under authority of Section 14 of the 1946 Flood Control Act, as amended. This legislation provides the Corps of Engineers authority for construction of emergency streambank and shoreline protection of public works and non-profit public services. The investigation was made in response to correspondence received from Congressman Charles A. Mosher in December 1976 regarding erosion problems and possible damage to sanitary sewer facilities at Elberta Beach and Linwood Park, Vermilion, OH. A copy of the correspondence is attached in Appendix A.

ACKNOWLEDGEMENTS AND COORDINATION

2. This report was prepared by Dalton, Dalton, Little, Newport, Inc., 3605 Warrensville Center Road, Cleveland, OH, under a contract with U.S. Army Engineer District, Buffalo.

AREA OF REPORT CONSIDERATION

3. The area considered in this report is located in the city of Vermilion, OH, on the southern shore of Lake Erie approximately 40 miles west of the city of Cleveland, OH, in Erie and Lorain Counties. Specifically, the Elberta Beach sanitary sewer pumping station, Location A, lies on city-owned property with approximately 150-feet of frontage on Lake Erie. Location B is in Linwood Park Development. A general location map is shown on Plate 2.

4. Area A - Elberta Beach (Photos 1 - 8): The Elberta Beach sanitary sewer pumping station is located on city-owned property with 150 feet of frontage on Lake Erie. The dimension of the concrete block structure is 12' x 12' with an entrance on the landward side of the building.

The station originally pumped sewage out into the lake through an outfall pipe which has since been destroyed by erosion.

5. The station presently pumps sewage from approximately 300 homes to a sewage treatment plant to the west. The pumping station is located 43 feet south of a 15-foot high bluff. The bluff is composed of a shale terrace with a clay and gravel material on top of the terrace. The top of the shale bench is approximately five feet above low water datum (568.6 IGLD); the clay and gravel layer is approximately 10 feet thick. The erosion of the bluff is slowed by the shale terrace, but during high lake stages and northeasterly winds the clay bank is directly exposed to wave attack. Evidence of groundwater seepage in the steep, unconsolidated bluff was not apparent during the field investigation. The present stability of the bluff indicates that groundwater seepage is not a cause of the erosion and that the major cause is direct wave attack at the base of the bluff. A location of the problem area is shown on Plate 3.

6. Area B - Linwood Park Development (Photos 9 - 14): The Linwood Park Development has approximately 4,200 feet of lake frontage. A sanitary sewer interceptor line runs parallel to the lake and is presently endangered by bluff recession along approximately 400 feet of shoreline. The field inspection of November 1976 showed that the easterly bluff had eroded 10 feet due to wave action since July 1975, and the closest proximity of the edge of the bluff to the sewer line was recently measured at 20 feet. Loss of the sewer interceptor would disrupt service to approximately 300 homes. A location map is shown on Plate 5.

FIELD INVESTIGATION

7. A field investigation was made in November 1976 by District employees to determine whether the Buffalo District Corps of Engineers could provide assistance in correcting the erosion problems at Elberta Beach and Linwood Park. This investigation was made in response to correspondence received from Congressman Charles A. Mosher. During that inspection, erosion at Location A had reached a point about 75 feet from the pump station. The erosion problem seems to be a direct result of the existing ground and shale being cut when the outfall pipe was installed. The backfill is quickly being washed away by wave action. Extensive erosion of the westerly adjoining property was also noted. Erosion at Location B, Linwood Park, had reached a point within 20 feet of the sanitary sewer interceptor line which runs east and west between Lake Avenue and the south shore of Lake Erie.

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8. A subsequent field investigation was made in June 1977 to determine possible remedial measures that were feasible from an economic and engineering standpoint to alleviate the erosion problem. On the day of the June field trip, waves were reported to be 10 to 12 feet high with winds of 40 to 50 mph from the northeast (See Photos 1, 3, 4, 13 and 14). This provided an accurate analysis of actual erosion taking place and this condition exceeded the actual design criteria.

DESIGN CRITERIA

9. The following information was used to obtain the design of the considered remedial measures. The detailed design analysis is included in Appendix B of this report.

a. Wind velocities were obtained from wind data collected by the U.S. Weather Bureau in the vicinity. These data, taken on an hourly basis, include wind velocity and direction.

b. Fetch length for Elberta Beach and Linwood Park was measured from a lake survey chart, and the effective fetch was calculated according to standards established by the U.S. Army Coastal Engineering Research Center (CERC). The effective fetch for irregular shoreline method was used as explained in the shore protection manual (SPM) Vol. I, by CERC. A design fetch length of 70 miles was used.

c. Based on guidance provided by North Central Division (NCD), the 200-year recurrence event was used as the design wave. This was calculated by combining the 10-year still water level (SWL) and the 20-year deep water wave.

d. The design wave was calculated using the following: (1) Report on Great Lakes Open Coast Flood Levels (Detroit District, Corps of Engineers, February 1977); (2) Shore Protection Manual (Coastal Engineering Research Center, 1973); (3) Design wave information for the Great Lakes, Report No. 1, Lake Erie (TR.H-76-1) (U.S. Army Waterways Experiment Station, Vicksburg, MS, January 1976). Refer to Technical Appendix, Sheets 1 through 5, for design results.

PROPOSED PLAN OF IMPROVEMENT

10. Location A, Alternate 1: The proposed plan of improvement to prevent further erosion at Elberta Beach will consist of pouring in place a reinforced concrete retaining wall as shown on Plate 4. This wall will be anchored on both sides back into the existing shale portion of

the bluff. The area behind the wall will be filled with four inch to eight inch rock and granular backfill and sloped up as shown on Plate 4 to meet the existing bluff. The bottom of the wall will be cut into and anchored to the existing shale base. One-ton stones will be placed as toe protection on the lake side of the proposed wall.

11. Location B: After considering the possible methods of protection at Linwood Park, a stone revetment was deemed the most suitable plan of protection for the bluff in the study area. Because this is a private beach, no additional benefits from use of the beach for public recreation would be realized to justify the cost. Cost of cellular steel or gravity-type concrete bulkheads exceeds that on stone revetments. These are also less suitable plans of protection, since vertical-faced structures are more likely to cause scour of the existing narrow beaches. Since the frontage will continue to be used by the private owners for recreational purposes, the preservation of as much beach as possible is desired. The proposed stone revetment would have a top elevation of 580, 10 feet above mean lake level. Its alignment would generally follow the existing toe of slope with the landward side of the revetment against the face of the bluff. The structure would have a one on two slope on its lakeward face. The armor stone shall be from 1,000 to 2,400 pounds with the underliner stone ranging from 60 to 150 pounds, and the filter media ranging from the Number 200 sieve up to a maximum of four inches. To protect the section of bluff which would be threatened during the 50-year life of the project would require construction of about 400 linear feet of revetment. A typical plan and cross section of the proposed revetment are shown on Plate 6.

12. The revetment is designed to armor the toe of slope in the zone of wave attack up to the limit of wave uprush. Under the most severe conditions, which will occur during periods of high lake levels, some settlement of the toe of the structure is expected due to scour. Sufficient stone is provided by the design cross section to permit such settlement and readjustment of the stone cover without exposing the bluff.

OTHER PLANS CONSIDERED

13. Location A: Alternative plans considered for protection of the sanitary sewer pump station were (a) a gabion structure and (b) relocation of the pump station. The gabion structure would be built in a similar location. The structure would consist of a gabion mattress apron placed on a leveled lake bottom. This mattress apron would provide stability to the structure and would insure against scour caused

by wave action. Similar dimensions would be used with the exception that the gabion wall would extend to the top of the bluff. Relocating the pumphouse would require complete rebuilding of the facility with a considerable amount of underground work involved to realign the existing gravity sewers and extend the force main. The cost estimates of the proposed work are shown in Paragraph 28.

14. The consideration for not selecting the gabion structure or the relocation was basically of an engineering and economic nature. During past experiences with gabions in an area subject to direct wave action, the gabions required considerably more maintenance than a concrete wall structure. Maintenance and ease of construction were also primary considerations for structure selection. Avoiding high maintenance costs was a prime consideration due to the limited budget and availability of maintenance personnel.

15. Relocation would require clearing and grading the site directly inland. This site is presently overgrown with large trees and heavy brush. The entire pumphouse would have to be reconstructed, and sewer lines would require realignment to the new facility. The existing structure would require demolition to remove and dispose of the building material.

16. Location B, Linwood Park: Alternative plans considered for the protection of the sanitary sewer interceptor were (a) to construct a rubblemound groin that would be tied into the bluff and would extend north approximately 150 feet out into the lake and (b) to relocate the existing sewer. Both of these plans would require a much longer construction period. Relocating the sewer main as shown on Plate 5 would require the streets to be closed while the new system is being installed, and service connections to all lakefront homes would require rebuilding.

EXISTING ENVIRONMENTAL CONDITIONS

Vegetation:

17. Location A, Elberta Beach: The steep bank slope along the shoreline immediately in front of the pumphouse is visibly eroded. This nearly vertical bank, containing exposed soils and roots, is directly subject to wind and wave action from Lake Erie. A shale terrace about five feet high extends outward in both directions beyond the project site. The area surrounding the enclosed pumphouse has dense woods on the east and across the road, south of the pumphouse. The north and west sides contain scattered trees and brush. This ground cover acts as a screen between the pumphouse and residential property to the west.

18. Location B, Linwood Park: The bank slope at the northeast corner of the park contains some large rocks and concrete chunks varying in size. The concrete appears to be the remains of steps leading down to the beach which have failed due to erosion. Trash and debris have washed up onto the shoreline in this area. Vegetation along the top of bank between the road and the top of bluff is well maintained by mowing. A row of large trees parallels the shoreline.

ENVIRONMENTAL CONSIDERATIONS

19. The study of environmental considerations was prepared so that an evaluation of the environmental impact can be made for the implementation of the selected plan of protection in the study areas.

20. At Location A, the recommended plan consists of constructing a concrete wall at the base of the bluff in the eroded area as previously described. The recommended plan at Location B consists of constructing a 400 linear foot stone revetment in the eroded area previously described.

21. The basic environmental data relative to the problem area were obtained from the 1966 report (geomorphology, littoral materials).

22. Geomorphology: The formation of the Lake Erie basin and the geologic characteristics of the surface materials of the Erie basin are the result of glacial action during the Pleistocene Age. Generally, the material overlying the bedrock is a glacial till composed of native material ground up beneath the glacier, mixed with material from the Canadian regions to the east and northeast. The composition of the till varies widely from place to place, but, in general, is a hard, compact boulder clay with the included rock fragments varying from sand to pebbles, cobbles, and large boulders. The analysis of the boulder clay found along the Ohio shoreline of Lake Erie indicates that approximately 75 percent is silt and clay, 15 to 20 percent is sand, and the remainder is coarser material. The surface material throughout most of the Ohio shoreline consists of lacustrine clay and silt. In localized areas, the surface material is sand, probably deposited as outwash from streams of the retreating glaciers. The bluffs have a history of progressive erosion from wave action, the rate increasing with the increase of lake levels.

23. The littoral material found in the bluff was gray silty clay with embedded shale fragments, traces of gravel, and thin layers of sand. The material conforms to the general characteristics of the Ohio shoreline bluffs described above, except that there is no evidence of coarse gravel and boulders ~~and a~~ correspondingly higher silt and clay content.

24. The beach material at Linwood Park is generally fine to medium sand. It is poorly graded, with most of the material between 0.2 and 0.4 mm in size. At the water's edge, the sand is better graded and somewhat coarser. Beyond the 6-foot depth, the shale bedrock is either exposed or covered with only a this layer of fine sand. The total supply of beach material is inadequate to provide a beach of the proportions required for protection of the shore during periods of normal or above-normal lake levels. Little or no beach exists at Elberta Beach. The shoreline consists of shale bedrock and shale fragments. Any material falling from the bluff is quickly carried away by wave action.

ENVIRONMENTAL IMPACT OF THE PROPOSED ACTION

25. The establishment of a concrete wall at Location A and a stone revetment at Location B will result in the stabilization of the damaged lake shore bluff, which has been severely eroded and undercut by wave action. It was estimated during this study that if natural erosion processes are allowed to continue unabated, then it is possible that both the sanitary pump station and the sanitary interceptor sewer could be destroyed within three years (by 1980) at the present erosion rate.

26. In view of present conditions, replacement of the eroded sections of bluff with a concrete wall and stone revetment should improve the aesthetic value of the Lake Erie shoreline at these locations.

27. Construction of the stone revetment will not disturb the peripheral terrestrial environment. Some noise, dust, and turbidity will be generated during actual construction at both locations. However, the Contractor performing the work will be required to minimize these effects according to the requirements outlined in the Corps of Engineers Regulation CE-1300 entitled "Civil Work Construction Guide Specification for Environmental Protection."

POTENTIAL SOCIAL IMPACTS

28. Without a Federal project, erosion will ultimately require the relocation of the pumphouse and the sanitary sewer interceptor line.

29. The social and economic burdens that the area residents will be forced to carry as a result of leaving the erosion unattended are as follows:

a. Loss of sanitary sewer facilities to approximately 300 homes at each location.

b. If either facility is destroyed, raw sewage will spill directly to the beach, then into Lake Erie.

ESTIMATES OF FIRST COSTS

30. Cost estimates were prepared for the recommended plans of improvements for Locations "A" and "B". These estimates were prepared with preliminary survey information and available office data for the area. These unit price cost estimates were made on the assumption that Contractor's costs include plant, labor, material, overhead, and profit (at June 1977 price levels). In addition to preparation of the cost estimates for the recommended plan at Location A, cost estimates were prepared for the alternate plans, namely gabions and pump station relocation, for cost comparison. At Location B, the cost estimate for the recommended plan was prepared. Cost estimates are shown in Paragraph 38.

31. Location A: Comparison of costs for alternate structural solutions were made assuming that the same layout would be sufficient to provide the required protection. The costs were determined by using current construction rates for the necessary construction quantities. A 25 percent contingency was used to provide for unforeseen delays, deficiency of detailed surveys, and possible oversights in the cost estimates. Supervision and administration include the cost for supervision, inspection, and overhead for the construction of the project. The supervision and administration costs for the gabion structure were assumed because of the necessary increase in quality control and inspection required for gabion construction. The following is a summary of the cost estimates for the three structural plans.

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COST ESTIMATES AT LOCATION "A"

32. Reinforced Concrete Wall (Selected Plan of Improvement)(1)

Item	Unit	Quantity	Unit Cost	Total Cost
Dewatering	LS	1	$13,000.00	$13,000.00
Concrete	CY	86	185.00	15,910.00
Reinforcing Steel	LB	7,500	0.35	2,625.00
Rock Anchors	EA	24	30.00	720.00
Dumped Rock	CY	35	24.00	840.00
Granular Backfill	CY	175	12.00	2,100.00
Subtotal				$35,000.00
Contingencies (25%)				9,000.00
Engineering, Design, Supervision, and Administration (30%)				11,000.00
Total				$55,000.00(1)
Gabion Structure				
Gabion Baskets (3 x 3 x 9) and Rock Fill	EA	26	$ 175.00	$ 4,550.00
Fiber Blanket	SY	85	0.75	63.75
Granular Backfill	CY	175	12.00	2,100.00
Subtotal				$ 6,713.75
Contingencies (25%)				1,678.44
Engineering, Design, Supervision, and Administration (30%)				2,014.13
Total				$10,406.32
Relocation of Pumphouse	LS			$65,000.00

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ESTIMATE OF ANNUAL COST - ELBERTA BEACH

33. Annual costs have been computed using an interest rate of 6-3/8 percent and a 50-year project life. The construction can be completed in one construction season. Annual maintenance costs have been included to provide for replacement and addition of stone as required.

First Cost - Elberta Beach =	$55,000.00
Annual Costs	
Interest 6-3/8%	3,509.00
Amortization (.0030)	165.00
Maintenance	300.00
Total	$ 3,974.00

ESTIMATE OF BENEFITS

34. Estimate of benefits for the project have been examined in light of physical damage prevented and business and emergency cost avoided and are given in June 1977 price levels.

35. Location "A" Elberta Beach (sanitary pumping station) - This facility is located 43 feet south of the present lake shoreline (pg. 1). The pump station also lies landward of a 15-foot high bluff consisting of clay and gravel on top of a shale bench. Failure of this sewage pumping station would impact upon 300 area residences and would be likely to produce significant disruption to the area, in addition to initiating emergency operations by local and State governmental agencies (town highway departments, town supervisors, county department of health, etc.). Benefits attributed to the proposed emergency shoreline stabilization measures are based upon estimated damages to lands or improvements that would occur without the proposed protection over a 50-year period. Damages were calculated using current market value of structures, or reconstruction and relocation costs of the affected improvements. The primary public facility at Location "A" consists of the sewage pumphouse and its contents.

1962 acquisition cost = $25,000.00
Useful life - 50 years
Straight line depreciation
No salvage value
Annual depreciation charge = $500.00
18 years depreciation to 1980 (18 x $500.00 = $9,000.00)

Remaining economic life by 1980 is $16,000.00
Present value of $16,000.00 in 1980 is $13,280.00

36. Loss of this remaining economic life of $13,280.00 is equivalent to an average annual loss of $890.00. The total relocation cost of $65,000.00 (Pg. 10) anticipated in 1980 has a present value of $53,950.00. Average annual relocation costs avoided are $3,600.00 and are considered to be benefits attributable to the proposed emergency bank protection plan.

37. Total average annual benefits consist of physical damage and relocation cost avoided and are estimated to be ($890.00 + $3,600.00) = $4,490.00. Annual cost = $3,974.00; annual benefits = $4,490.00; benefit-cost ratio for the construction of a reinforced concrete wall at Location "A" is 1.0 to 1.14.

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COST ESTIMATES AT LOCATION "B"

38. Stone Revetment*

Item	Unit	Quantity	Unit Cost	Total Cost
Mobilization and Demobilization				$ 500
Armor Stone	Ton	3,200	$22	70,400
Underlayer Stone	Ton	1,400	19	26,600
Run of Bank Sand and Gravel	Ton	2,100	6	12,600
Construction of Ramp and Haul Road				600
Total Construction Costs				110,700
Contingency (15% ±)				16,800
Engineering and Design Supervision and Administration (15% ±)				19,050
Total First Cost				146,050

*A detailed cost estimate is enclosed in the Technical Appendix of this report.

ESTIMATE OF ANNUAL COSTS - LINWOOD PARK

39. Annual costs have been computed using an interest rate of 6-3/8 percent and a 50-year project life. The construction can be completed in one construction season. Annual maintenance costs have been included to provide for replacement and addition of stone as required.

Total First Cost	$146,050
Average Annual Cost (.0668)	9,756
Annual Maintenance	1,200
Total Annual Costs	10,956

ESTIMATE OF BENEFITS

40. Estimate of benefits for the project have been examined in light of physical damages prevented and business and emergency costs avoided and are given in June 1977 price levels.

PHYSICAL DAMAGE PREVENTED

41. Location "B" Linwood Park Development (sewer interceptor line) - Approximately 400' of shoreline has eroded to within 20 feet of an existing sanitary sewer interceptor line parallel to the lake and is presently endangered by continued bluff recession. Loss of the interceptor line would disrupt at least 300 homes and would have adverse environmental effects if raw sewage was spilled directly onto the beach or into Lake Erie. Benefits attributed to the proposed shoreline protection would eliminate the need to relocate the line in the future and also prevent the loss of the remaining useful economic life of the sewer line. The present value of these future losses and the average annual damages were computed as follows:

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SUMMARY OF EMERGENCY COSTS*

Emergency Pumping	$ 9,750
Rental and Servicing of Portable Latrines	6,750
Rental and Servicing of Holding Tanks	20,700
Clean-up and Testing Costs	10,000
Total Emergency Costs	47,200

*Analysis in Appendix C

SEWAGE LINE RELOCATION

Cost of Pipe plus Installation 3,000' at $30 per lin. ft.	$90,000
Cost of Manholes 5 at $2,500 ea.	12,500
Land Acquisition and Resetting Lateral Intercepts	40,000
Total Relocation Costs	142,500
Total Costs (Relocation and Emergency)	189,700
Contingency (15% $\pm$)	28,500
Total Costs	218,200
Average Annual Benefits (0.0668)	14,600

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42. Average annual benefits consist of emergency and relocation costs avoided and are estimated to be $14,600. Average annual costs consist of the construction of the stone revetment plus annual maintenance, which is estimated to be $10,956. Benefit-cost ratio for the construction of a stone revetment at Location "B" is 1.3.

LOCAL COOPERATION

43. No difficulty is anticipated with respect to local cooperation. The local cooperation required for the plan of improvement would be in accordance with current Federal policy and a socially acceptable remedial plan of improvement. The construction of the improvements will provide erosion protection for the sanitary pump station at Elberta Beach and the sewage line at Linwood Park. The Reconnaissance Report shows that there is a Federal interest in providing such protection and that the local cooperating agency is willing and able to provide the necessary assurances. Local interests would be required to:

a. Provide, without cost to the United States, easements and rights-of-way for the construction of the project.

b. Hold and save the United States free from all claims for damages incident to construction of the project.

c. Take over and maintain the project and the remaining embankment slope after completion without costs to the United States in accordance with regulations prescribed by the Secretary of the Army.

d. Assume responsibility for all costs for protection of private property in the vicinity of Elberta Beach.

e. Assume responsibility for all costs in excess of the Federal limitation of $250,000.

44. Current regulations and policy for Section 14 continuing authority program (ER 1105-2-507, Para. 8B, dated 15 April 74) state that an environmental impact statement is not required for emergency actions which do not permit delays necessary to process environmental statements. Therefore, an environmental impact statement is not required for this project. Further, the environmental assessment for the proposed projects indicates that the construction will not have a major impact on the environment.

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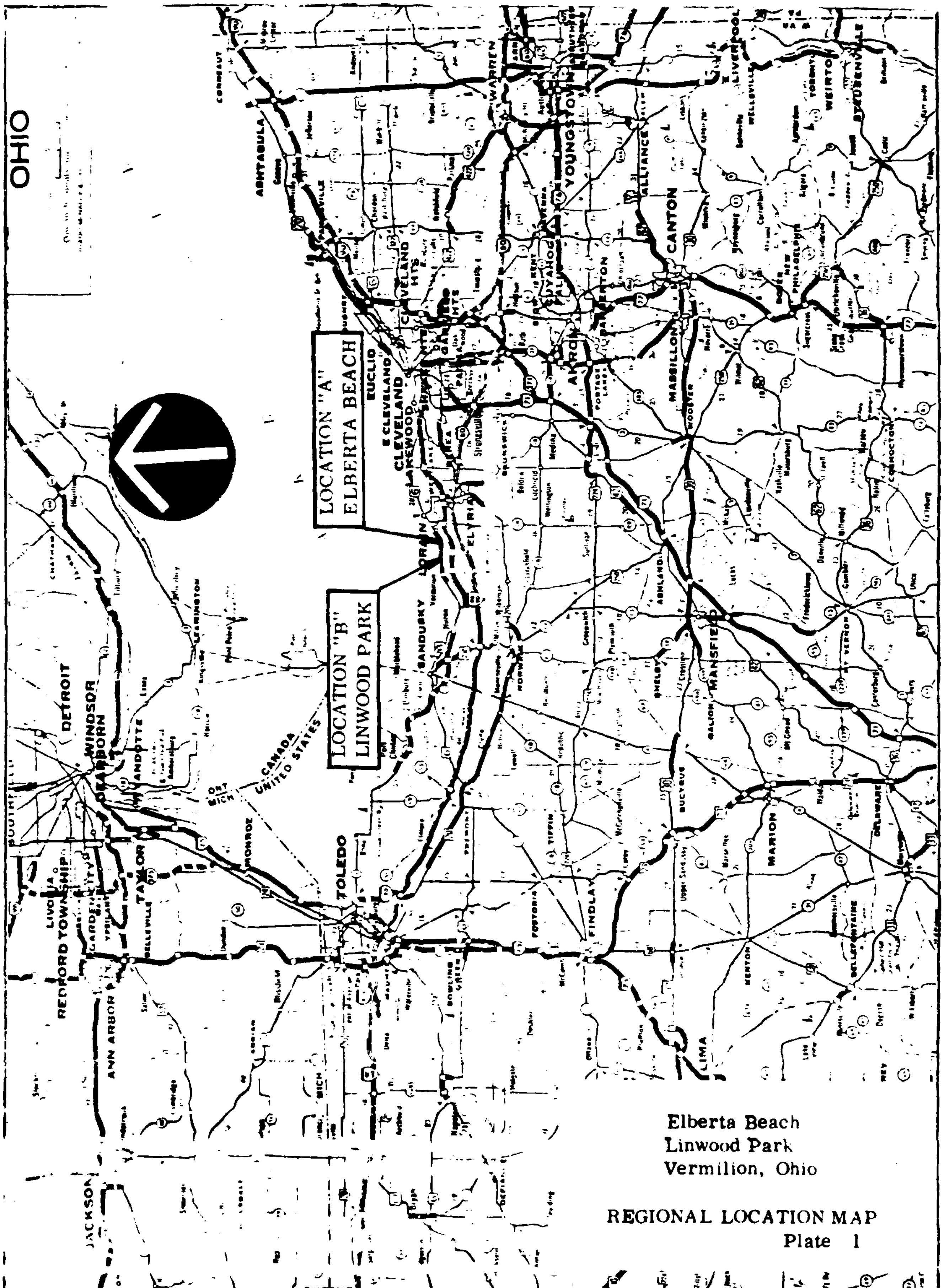
RECOMMENDATION

45. All work under Section 14 of the 1946 Flood Control Act as amended is required - under existing legislation, regulations and policies - to be economically justified. The economic justification requires that the benefit-cost ratio be equal to or more than 1.0. For the proposed improvement, the benefit-cost ratio is 1.14 at Location "A", Elberta Beach, indicating that an economically feasible plan of improvement can be developed. At Location "B", Linwood Park, a benefit-cost ratio of 1.3 also indicates that the project can be economically justified. Thus it is recommended that funds be allocated for the construction of remedial measures as outlined in this report to protect the sanitary pump station at Elberta Beach and the sewage line at Linwood Park, under the authority of Section 14 of the 1946 Flood Control Act, as amended.

Daniel D. Ludwig

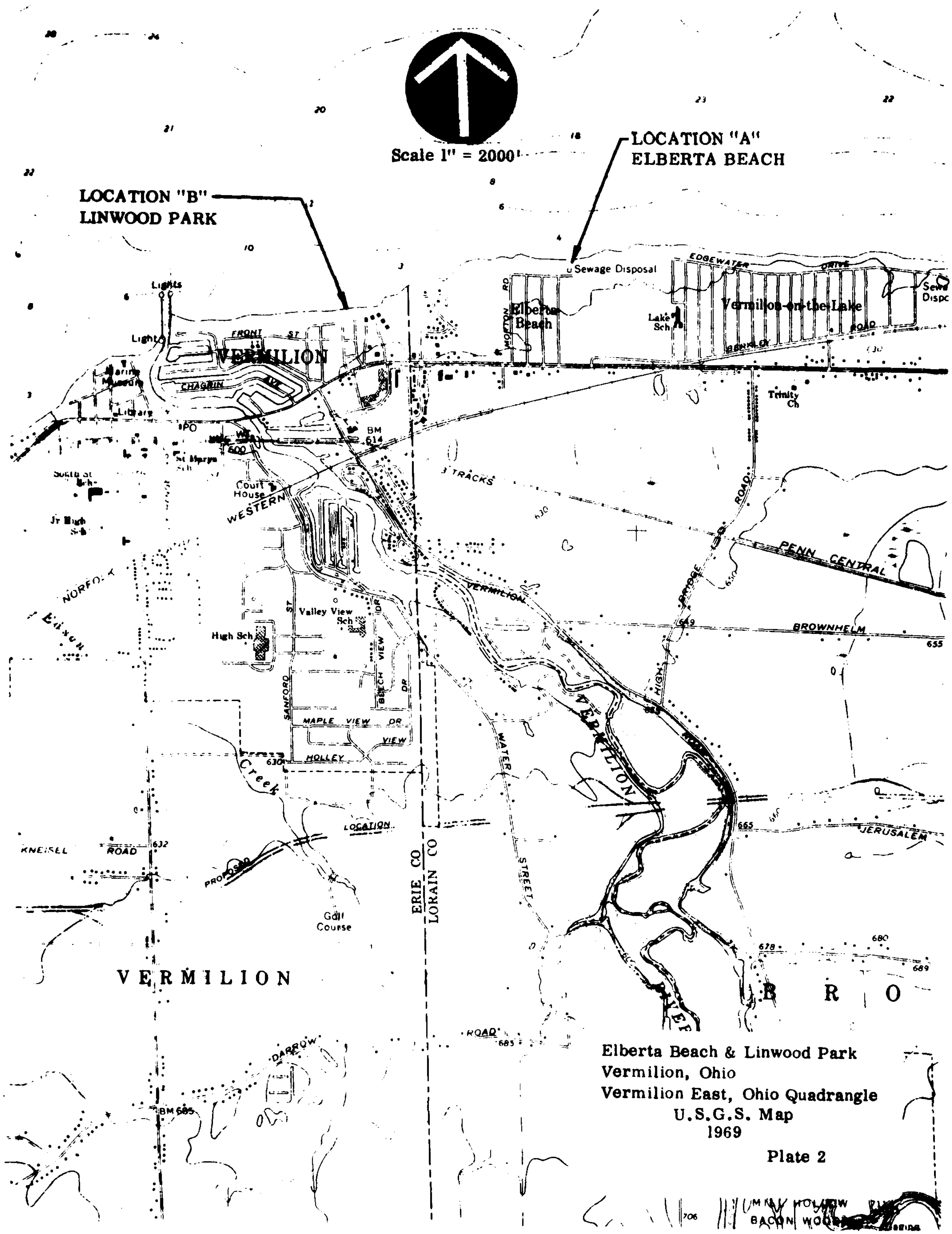
Incl (10 cys)
as

DANIEL D. LUDWIG
Colonel, Corps of Engineers
District Engineer



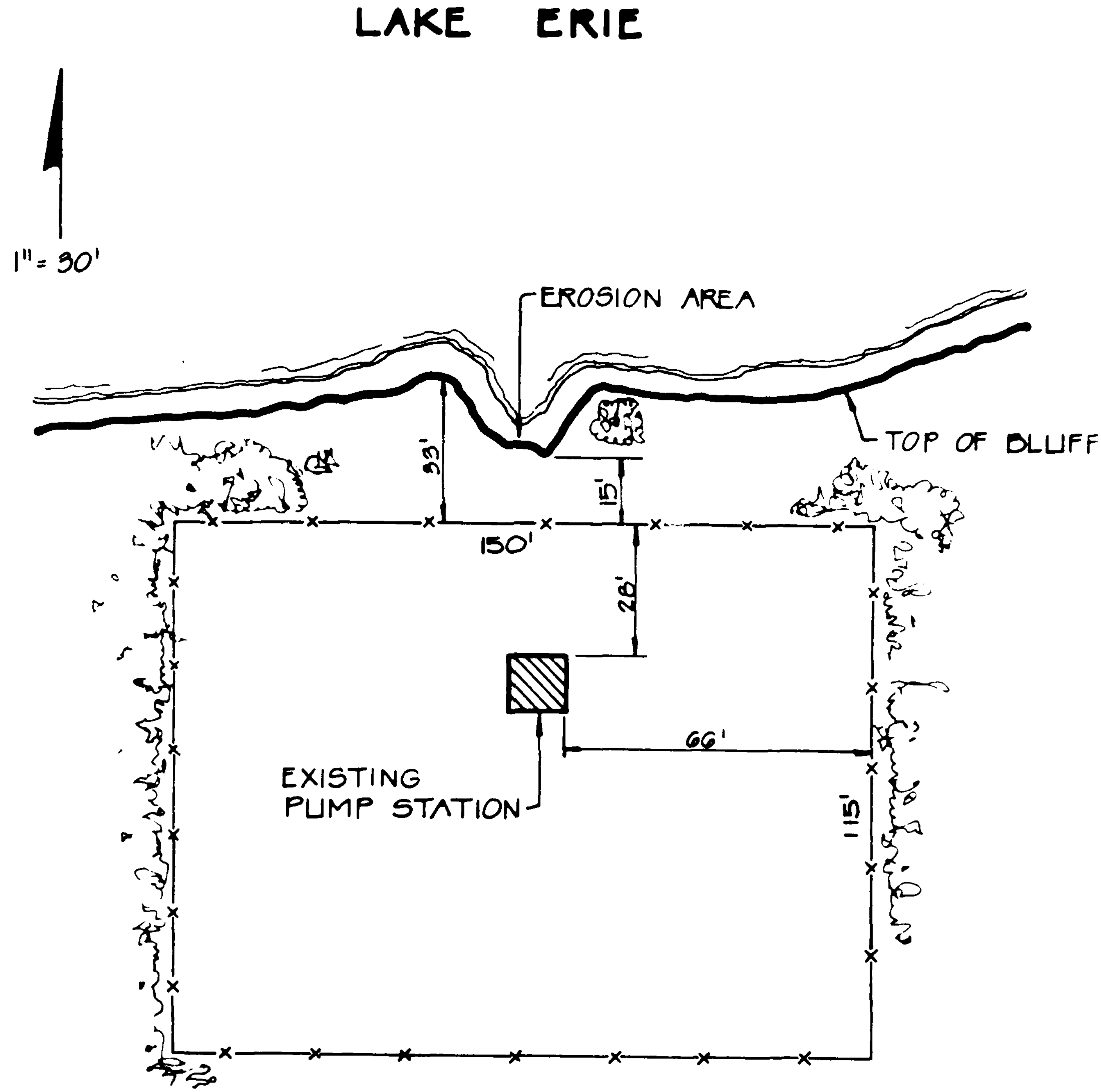
Elberta Beach
Linwood Park
Vermilion, Ohio

REGIONAL LOCATION MAP
Plate 1



Elberta Beach & Linwood Park
Vermilion, Ohio
Vermilion East, Ohio Quadrangle
U.S.G.S. Map
1969

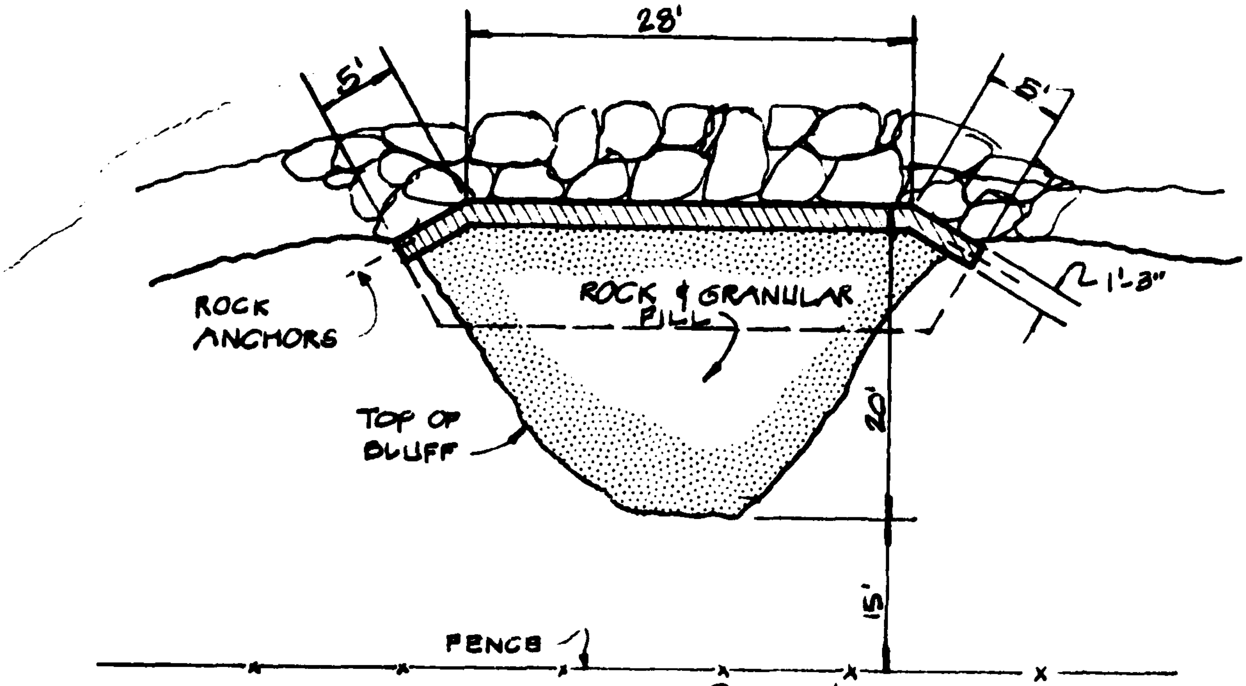
Plate 2



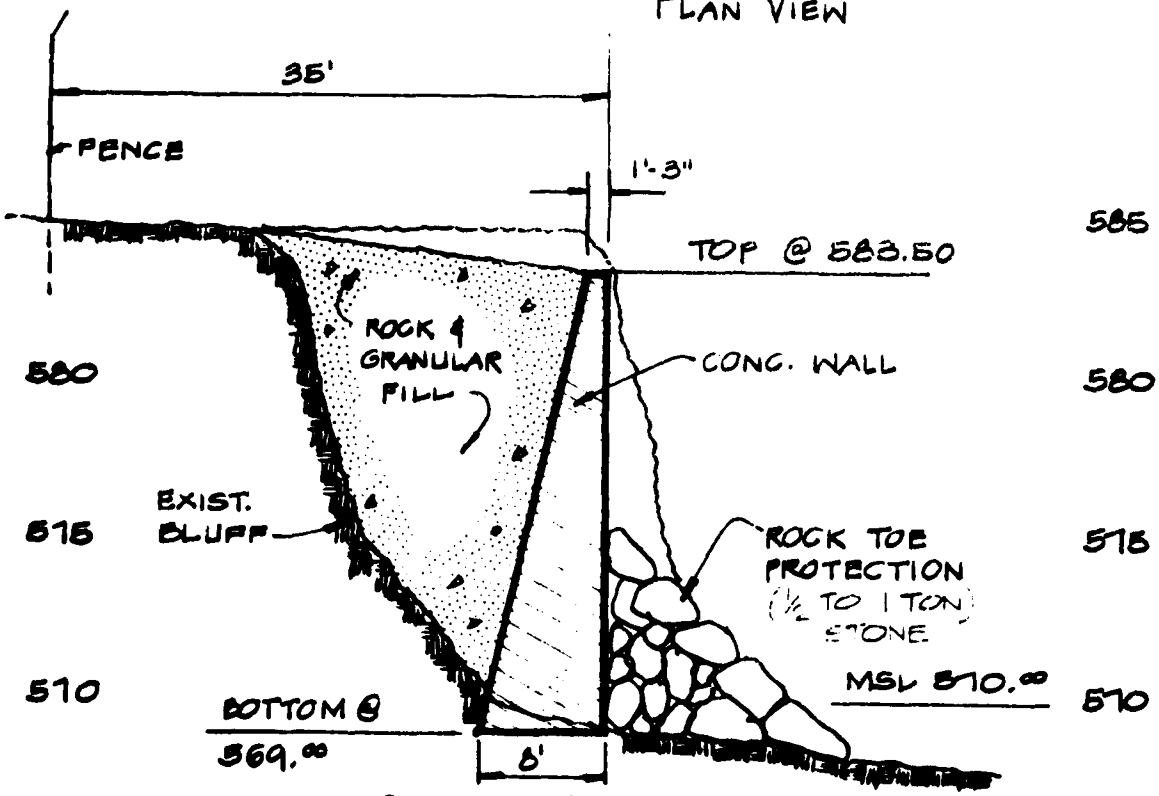
ELBERTA BEACH PUMP
STATION

LOCATION "A"
ELBERTA BEACH

BY JSS. DATE 8-11 SUBJECT ELBERTA BEACH SHEET NO. OF
CHKD. BY DATE JOB NO.
DALTON-DALTON-LITTLE-NEWPORT

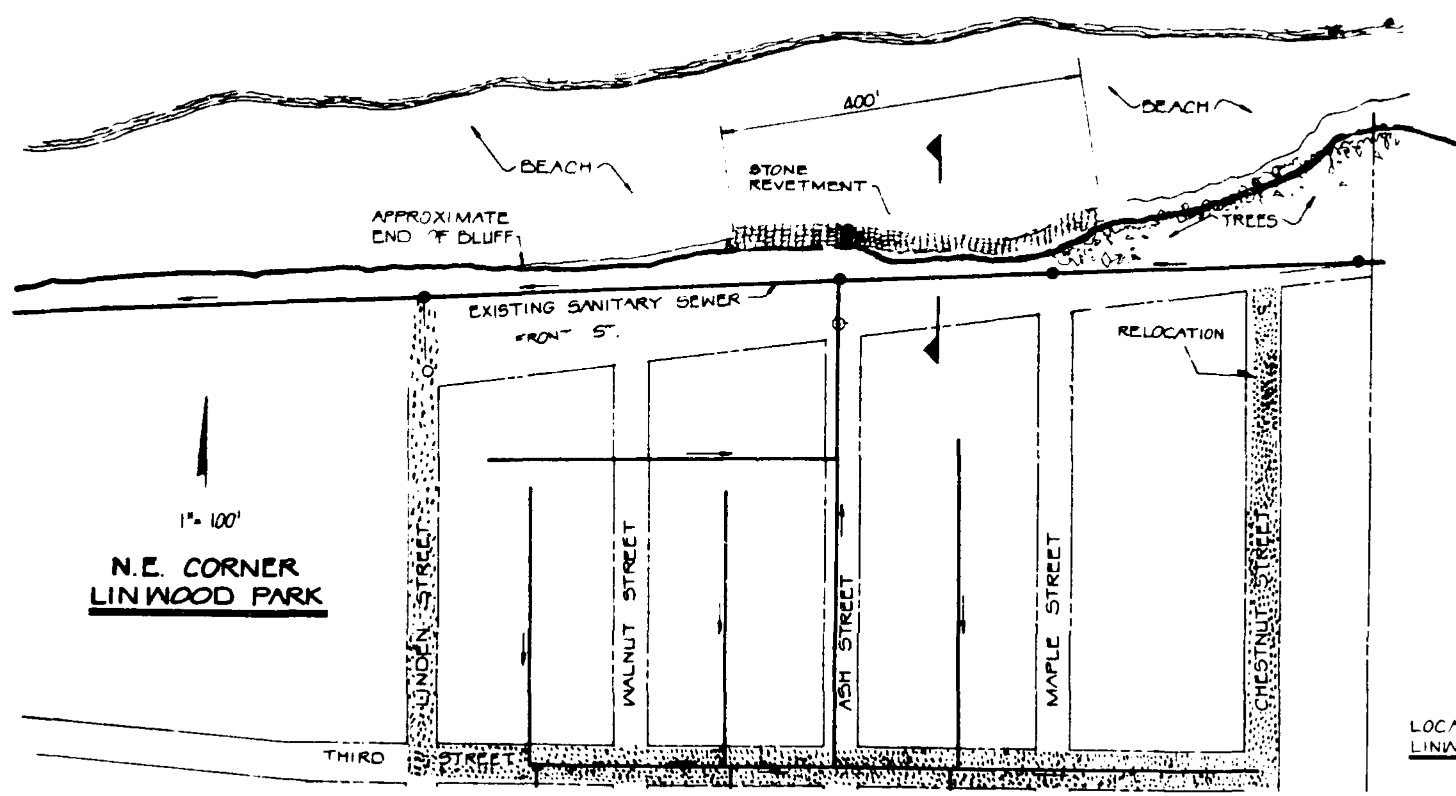


PLAN VIEW



SECTION VIEW

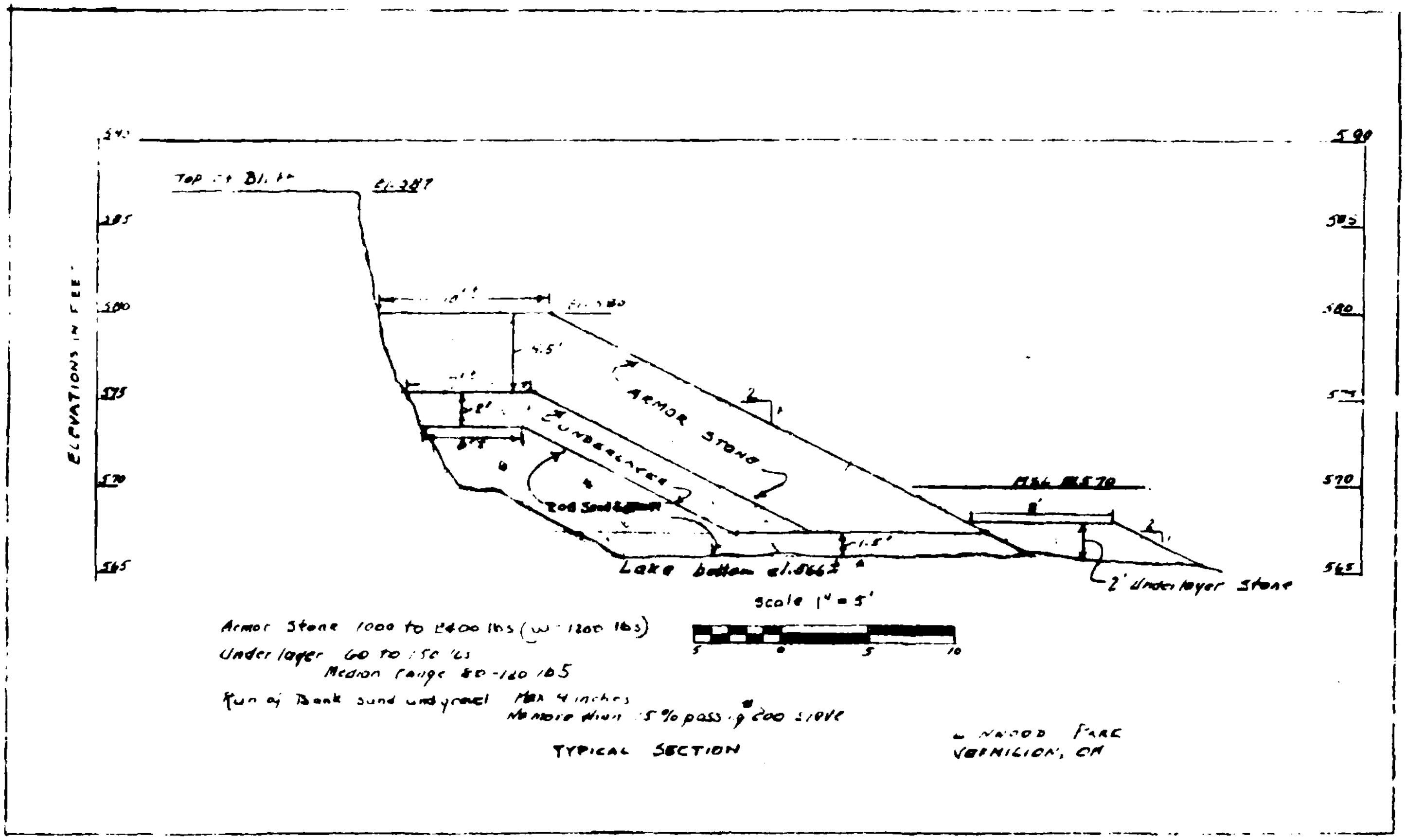
LOCATION "A" ELBERTA BEACH
PLATE 4



N.E. CORNER
LINWOOD PARK

LOCATION 'B'
LINWOOD PARK

PLATE NO 5



ELEVATIONS IN FEET
Top of Bluff
Armor Stone
Underlayer
Lake bottom el.566±
MLW El.570
2' Underlayer Stone
Scale 1" = 5'
Armor Stone 1000 to 2400 lbs (W=1200 lbs)
Under layer 60 to 150 lbs
Median range 80-120 lbs
Run of Bank sand and gravel Max 4 inches
No more than 5% passing #200 sieve
TYPICAL SECTION
VERMILION, OH

Plate No. 6

Photo 1 Location "A" Elberta Beach.
Looking east across the face of the bluff in front of the existing pump station.

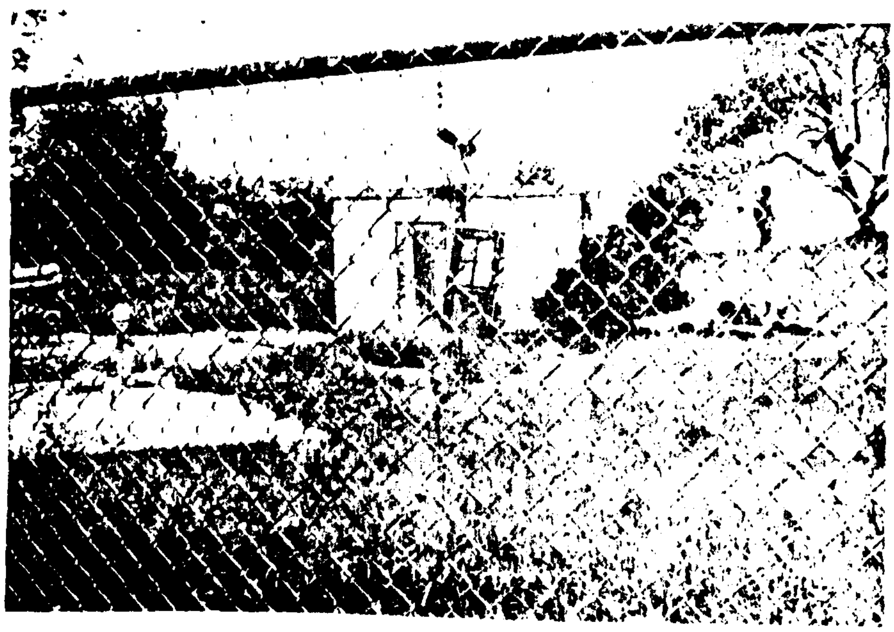


Photo 2 Location "A" Elberta Beach.
Looking north, existing pump station.

Photo 3 Location "A" Elberta Beach.
Looking east at bluff erosion. (Note: wave run-up).

Photo 4 Location "A" Elberta Beach.
Looking east across erosion area. (Note: wave run-up).

Photo 5 Location "A" Elberta Beach.
Looking west at existing concrete groins.

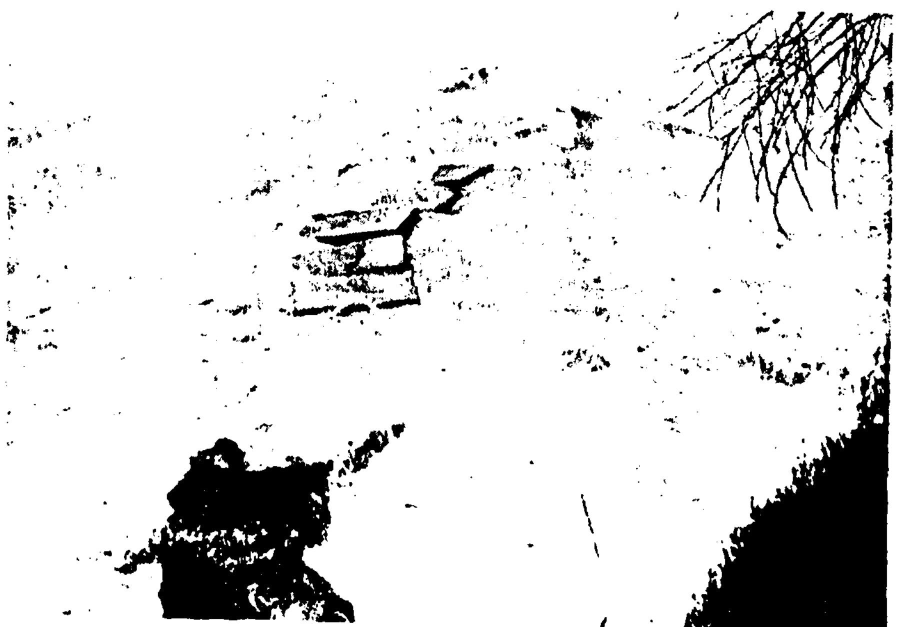


Photo 6 Location "A" Elberta Beach.
Existing concrete groin in front of pump station.

Photo 7 Location "A" Elberta Beach.
Erosion damage to outfall pipe.

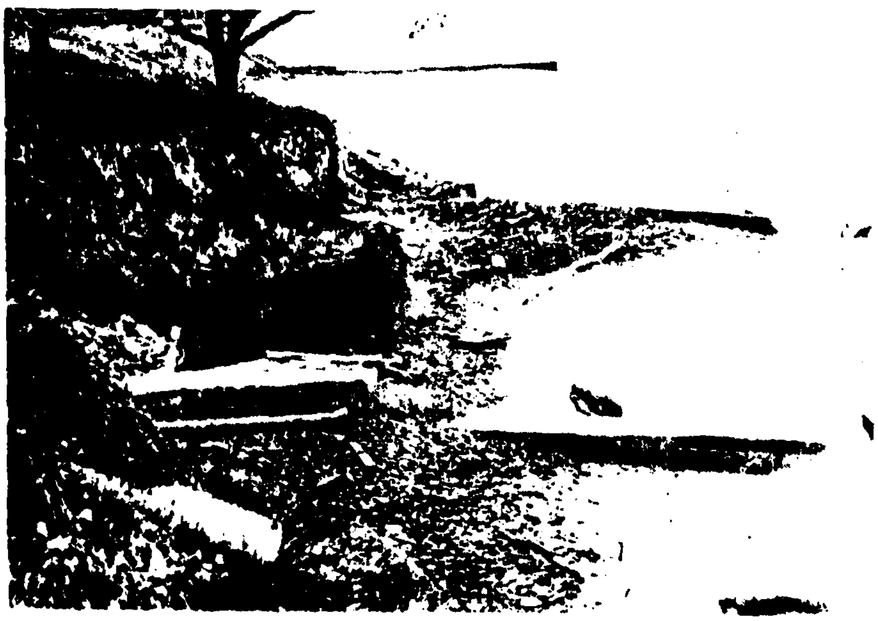


Photo 8 Location "A" Elberta Beach.
Erosion to bluff on the westerly adjoining property.

4

Photo 9 Location "B" Linwood Park.
Looking east, sanitary sewer interceptor line runs between the tree line and the road.

Photo 10 Location "B" Linwood Park.
Typical bluff erosion along study area.

Photo 11 Location "B" Linwood Park.
Existing steps protected from possible erosion by sand bags.

Photo 12 Location "B" Linwood Park.
Existing steps destroyed by bluff erosion.

Photo 13 Location "B" Linwood Park.
Looking east across erosion area.

Photo 14 Location "B" Linwood Park.
Looking east across erosion area.

APPENDIX A

CORRESPONDENCE

George W. Grossman
17125 Amber Drive
Cleveland, Ohio 44111

July 6, 1977

Mr. Charles Hill
Dalton-Dalton-Little-Newport
3605 Warrensville Center Road
Shaker Heights, Ohio 44122

Dear Mr. Hill:

Thank you for the opportunity to discuss the Section 14 study on the Linwood Park sewer problem. I would like to bring the following points to your attention:

1. The underlying rock on the shoreline is Devonian shale. At a point about 100' west of the Linwood-Nakomis line, the shale drops from about 8-10' above lake level to near lake level. East of Linwood Park, the shale bluffs erode at about one foot per year. Within Linwood Park, the soil is a buried valley deposit overlaid with glacial till. It is a clayey soil that is easily excavated. Under wave attack, such soils can be expected to erode at a rate in the order of 5-10 ft./yr.

2. The original sewers in Linwood Park had laterals in the streets and pitched to a main just below the bluff on the beach. The manhole for the outfall is still visible on the beach. The present sewers have laterals located between the cottages on the east side and also pitch to the lakeshore with the natural contour. The main is above the bluff about 2' north of the road edge on the east side. It runs at the base of the bluff from the center of the park westward.

3. The main is located entirely on the private property of the Linwood Park Company. The extent of the easement or if an easement exists is not known. In all probability, a new easement would be required.

4. The maximum distance the sewer main could be moved is about 20' on the east side of Linwood and about 30' on the west side. Further movement would interfere with trees and private leaseholds. The cottages are built on 99-year leases, renewable forever without fee. It is unlikely that lakefront leaseholders would agree to a sewer main under their front porches, and the cost would be prohibitive.

5. A 20' or 30' relocation of the sewer main can be expected to have a life of only 5 to 15 years in the easily erodable soil. Rains are already causing the bluff to slump in those areas where wave action has undercut the bluff. The east bluff has been exposed to wave runup in two NE storms this spring. A relocation would have to be protected by a revetment or a beach.

6. The littoral drift in the area is westward. Interference with NW waves by the breakwater has caused an accumulation at the east pier. The shoreline at the east pier is 150' from the end of the pier. The slope of sand underwater behind a breakwater is about 22-1. With a 12' deep channel from low water datum, the channel averages 13' to 14' deep off the east pier. Thus, the east pier is not a littoral barrier and will not be a barrier until the shoreline recedes to about 300' from the end of the east pier. When such a recession occurs, the entire beach will recede 150'.

7. The sand accumulation at the east pier is a hazard to public navigation channels and objectionable to Lagoons residents. Some sand is currently being hauled away by the city to fill in local ball diamonds.

8. Sand can be hauled 3000' down the beach by elevated scraper for about $2.00/cu. yd. These figures are from Terex Div., GMC, Hudson, Ohio. They have been confirmed by local bids.

I believe that a sewer relocation and revetment would be too expensive to be justifiable on a cost-benefit basis under Section 14. The restoration of Linwood beach would be an obvious and very beneficial way to protect the sewer lines. However, I understand that benefits accruing to private interests cannot be considered under this law.

Inasmuch as the breakwater has caused the sewer to be exposed to wave action and the total problem is under consideration in a Section 111 study and an Adverse Impact Study, I conclude that the protection of the sewer should be considered as part of these studies. I will request that the Corps include your report in both.

I would appreciate if you would include these comments in the report and also forward two copies of the draft report for study when it is available.

Sincerely yours,

George W. Grossman

cc: Colonel Daniel D. Ludwig

THE LINWOOD PARK CO.

ESTABLISHED 1883

ON LAKE ERIE

VERMILION, OHIO 44089

1070 WILBERT RD.
LAKEWOOD, OHIO 4410

June 27, 1977

Mr. Charles A. Hill, P.E.
Dalton-Dalton-Little-Newport
3605 Warrensville Center Road
Cleveland, Ohio 44122

Subject: L.W. Curtis ltr 6/15/77
Secc. 14 Shore Erosion Study

Dear Mr. Hill:

The Linwood Park Company is an Ohio Corporation, founded in 1883 and has been operating continuously since then. Its affairs are managed by seven Directors, elected by the shareholders. It owns all of the Linwood Park and leases the lots on a ninety-nine year basis to the residents. Of the 150 units in the Park, twenty-five are being occupied as permanent year 'round residences. Approximately 60% of the land remains open; no building lots have been sold since the early 1940's. It is our policy to maintain the open land in its present proportion.

In 1922 the Company granted an easement to the Town of Vermilion to be used for a main sewer line running East-West along the lake bank, extending approximately a half mile between our property lines. The main also serves all of the community of Nakomis to the east of Linwood. Park lines, then existing, connect into the main line. One of the conditions in granting the easement was that the town would be responsible for maintaining the main line.

Since the record high water level of 1973 lake bank erosion has been extremely rapid on the eastern one third of the bank. We have lost fifteen to twenty trees, some over thirty-six inches, which were planted years ago solely for bank protection. More trees are in jeopardy. In some places erosion has worked back to within thirty feet of the sewer li making the situation critical.

We have attempted self-help at considerable expense; reinforcing the toe and part of the bluff with sand bags, lake rock, sand, and drift logs without success. Our efforts have possibly slowed down the action, but at this point it is not even a holding action with the majority of the trees washed out.

In the last two years or so our problem has compounded. Wave erosion has changed a stable, sloping bank to a sheer bluff. The result is that we are now faced not just with erosion at the base, but erosion from above from rain, frost and wind. The rate of recession toward the sewer line

has rapidly increased and will continue to do so without remedial action. This observation is confirmed in Michigan's Demonstration Erosion Control Program Evaluation Report, 1974.

No commentary on the problem would be complete without reference to lake levels. There are some who believe long term lake levels are cyclical in nature and that we are now in the early stage of a low level cycle; the conclusion being that erosion problems will be minimal in the period ahead. The International Joint Commission reported as follows in their study of Great Lakes Levels:

> "A hundred years of record-keeping has indicated no regular, predictable cycles of levels. The interval between periods of high and low water can vary widely. - - - - - - - - - - - Wind, combined with barometric pressure differences can cause unusual local water level changes. The effects of winds and the waves they generate are the major cause of damage due to flooding and shore erosion. Even if the levels of the lakes were held to their long-term average, flood damage would still occur in periods of extremely high winds."

Lower lake level will not provide the answer to saving the Linwood/Nakomis sewer line. Even with Lake Erie within a few inches of the seventy-five year average, a June, 1977 NE storm brought the waves to the toe of the bluff on the east Linwood beach causing more erosion. The storm was not particularly severe compared with others which have occurred during the summer season in the past. It should be noted that prior to the storm there was approximately one hundred feet of protective sand beach in front of the bluff.

One other point should be considered with respect to "average" lake level and height of a system for bluff protection. An ENE, NE, or NNE storm lasting twelve hours or more, and this is not uncommon, can cause a pile-up of water at the Vermilion area reaching six feet. Under this circumstance "average" water level is of little consequence; serious erosion is inevitable.

In our opinion protection of the sewer line is not only critical but urgent; otherwise it will be bared and destroyed. The bluff can no longer protect it. Some mechanical means other than the ones we have attempted is mandatory.

Thank you for this opportunity to comment. Should further information or clarification be needed, we shall be glad to help.

Sincerely,

THE LINWOOD PARK COMPANY

R.S. Cheheyl

R. S. Cheheyl
President

RSC:mas

The City of Vermilion

P O BOX 317

VERMILION, OHIO 44089

ROBERT SWANKER
City Engineer

June 22, 1977

Dalton, Dalton, Little and Newport
Architects-Engineers-Planners
3605 Warrensville Center Road
Cleveland, Ohio 44122

Attention: Charles A. Hill, P.E.

Re: Section 14 Shore Erosion at Linwood Park and Elberta Beach in Vermilion

Dear Mr. Hill:

This is in response to your June 15, 1977 letter on the above subject.

During the four years time I have served this city as City Engineer I have observed continued erosion loss of land in the vicinity of the sewage pumping station on the north side of Edgewater Road east of Niagara Road in the Elberta Beach area and also in the vicinity of the intersection of Front and Maple Streets in the Linwood Park area. A city sanitary sewer runs parallel with Front Street just north of the pavement.

On October 21, 1976 I wrote to the Corps of Engineers (Buffalo) and requested that they review our problem of the potential damage to or loss of the pumping station and sanitary sewer.

Sincerely yours,

Robert L. Swanker, P.E.
City Engineer

RLS:jmb

sw/2143

NCBED-PF

23 May 1977

Robert Swanker, City Engineer
P.O. Box 317
Vermilion, OH 44089

Dear Mr. Swanker:

The purpose of this letter is to inform you that I have initiated a reconnaissance investigation for possible Federal assistance of the erosion problem to the sanitary sewer system in the Elberta Beach and Linwood Park areas, Vermillion, OH.

The Corps of Engineers has authority to provide erosion control under Section 14 of the 1946 Flood Control Act. Under this authority, all work must be engineeringly feasible, environmentally sound and economically justified. The reconnaissance investigation will determine if the remedial measures would meet these requirements. The expected completion date of the reconnaissance investigation and report is August 1977. My staff will coordinate with the non-Federal interests to explain the necessary assurances and requirements that might be needed for proposed improvements.

Sincerely yours,

DANIEL D. LUDWIG
Colonel, Corps of Engineers
District Engineer

Nance____

Pieczynski_

Gilbert___

Liddell___

Walker____

Ludwig____

CF:
✓NCBED-PF
NCBRO
Robert Teater, Director
Columbus, OH 43224

sw/2143

NCBED-PF

7 April 1977

SUBJECT: Section 14 Reconnaissance Report Initiation for Linwood-Elbenta Beach, Vermillion, OH

Division Engineer, North Central
ATTN: NCDPD-PF

1. In accordance with ER 1105-2-50, a reconnaissance report will be prepared for Linwood-Elbenta Beach, Vermillion, OH under authority of Section 14 of the 1946 Flood Control Act.

2. Initiation of the study at Vermillion is scheduled for May 1977 with the expected completion date of July 1977. The cost of preparing the reconnaissance report is estimated not to exceed $5,000.

BYRON G. WALKER
LTC, Corps of Engineers
Acting District Engineer

CF:
NCBED-PF

Nance________

Pieczynski____

Gilbert______

Liddell______

Walker_______

Ludwig_______

bb/2143

NCBED-PF 27 December 1976

Honorable Charles A. Mosher
House of Representatives
Washington, DC 20515

Dear Mr. Mosher:

This is in reply to your letter of 13 December 1976 concerning potential erosion damage to the sanitary sewage system in the Linwood Park and Elberta Beach areas, adjacent to Vermilion Harbor, OH.

My staff has recently visited the area, and beach surveys were taken during December 1976. The field inspection and survey data show a marked improvement in the condition of Linwood Beach compared to that existing during the past summer. The Section 14 reconnaissance study referred to in your letter is scheduled to be accomplished by my office in Fiscal Year 1978. I intend to closely watch the situation. If the improving trend reverses, I will consider a rescheduling of the study.

I have enjoyed working with you on the many water resource problems in your district. From my viewpoint, you have served your constituents well. It is most gratifying to know that Bette Welch will remain in her present capacity, and you may be sure that I will continue to work closely with Mr. Pease.

I want to wish you a happy holiday season and a rewarding and enjoyable retirement.

Sincerely yours,

DANIEL D. LUDWIG
Colonel, Corps of Engineers
District Engineer

CF:
HQDA (DAEN-CWA-D) w/incmg corres
NCDED " "
PAO " "
Exec Ofc " "
NCBED-PF " "
NCBPO " "

Honorable Charles A. Mosher
Representative in Congress
[illegible] E. 28th Street
Lorain, OH 44055

Pieczynski ________
Gilbert ________
Liddell ________
Walker ________
Ludwig ________

OFFICE OF TECHNOLOGY ASSESSMENT
MEMBER OF GOVERNING BOARD

Congress of the United States
House of Representatives
Washington, D.C. 20515

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COUNTY ADMINISTRATION BUILDING
MEDINA, OHIO 44256
(216) 725-6120

MUNICIPAL BUILDING
BARBERTON, OHIO 44203
(216) 848-1001

December 13, 1976

Daniel D. Ludwig
Colonel, District Engineer
Department of the Army
Buffalo District, Corps of Engineers
1776 Niagara Street
Buffalo, NY 14207

Dear Colonel Ludwig:

Some time ago we were in touch with your office, to request every assistance possible to control erosion damage in the Vermilion Harbor area, under authority the Corps has by virture of Section XIV of the 1946 Act.

Now we are advised that the sanitary sewerage system in the Linwood Park area and the Elberta Beach area, adjacent to Vermilion Harbor, will suffer considerable damage in the immediate months ahead if shore erosion in those areas remains uncontrolled.

Please accept this letter as my urgent request that your office undertake the necessary study to determine the capability of Section XIV at the earliest possible time.

I am aware of your current work load, and very mindful that I will be retiring from the Congress effective January 3. With this in mind, I respectfully request that you do me the favor of keeping in close touch with my successor, Member-elect Donald J. Pease, to keep us advised as to what you can do for Linwood Park and Elberta Beach. Of course, you can continue to call upon my Administrative, Assistant, Bette Welch, who will be serving in that same capacity with Mr. Pease.

We hope we may have a favorable reply from you in the very near future. Best personal regards.

Sincerely,

Charles A. Mosher
Representative to Congress

Mayor Arthur R. Crow

greco/2275

NCBED-PF

15 November 1976

Mr. Robert Swanker, City Engineer
P.O. Box 317
Vermilion, OH 44089

Dear Mr. Swanker:

This is in reply to your letter of 21 October 1976, requesting assistance under Section 14 of the 1946 Flood Control Act, to control erosion damage to the sanitary sewer system at Linwood Park and Elberta Beach.

Our preliminary investigation indicates that Section 14 may be applicable. I will initiate a reconnaissance study to determine the applicability of Section 14 as soon as my present workload will permit. I will notify you when the reconnaissance study is initiated.

Sincerely yours,

DANIEL D. LUDWIG
Colonel, Corps of Engineers
District Engineer

Sloan
~~Lombardo~~
Pieczynski
Gilbert
Liddell
Walker
Ludwig

CF:
NCBED-PF

The City of Vermilion

VERMILION OHIO 44089

[illegible] SWANKER
[illegible]

October 21, 1976

Colonel Daniel Ludwig
U.S. Army Corps of Engineers
Buffalo District
1776 Niagara Street
Buffalo, New York 14207

Dear Sir:

Please be advised that it appears to me that because of continued natural erosion of the south shore of Lake Erie this City will suffer damage to its sanitary sewerage system within one or two years.

One endangered section of sewerage parallels the lake shoreline in the "Linwood Park" section of this City.

Another endangered facility is a sewage pumping station in the "Elberta" section of Vermilion.

I understand from Congressman Mosher that the Corps has authority to provide planning and financial assistance to this municipality under Section 14 of the 1946 Flood Control Act.

Will you please consider this problem and advise me as to what further steps this City should take to solve this problem before it develops into an emergency.

Sincerely yours,

Robert L. Swanker, P.E.
City Engineer

RLS/mel
cc: Robert Cheheyl, Pres., Linwood Park Co.
Clerk of Council, Vermilion City
[illegible]
[illegible]

NCBED-PS

bs/236
28 March 1975

Robert Swankes, City Engineer
P. O. Box 317
Vermilion, OH 44089

Dear Mr. Swankes:

The purpose of this letter is to advise you of the results of our 25 February 1975 field inspection of the erosion problem at the Elberta Beach Sewage Pumping Station.

Our preliminary analysis of the situation indicates that the primary problem is caused by seepage of local ground water through the face of the bluff. The bedding material around the abandoned sewer outfall is probably acting as a drainage corridor for the ground water. As the face of the bluff becomes saturated, pieces fall to the beach and are carried away by lake action.

Since I have no authority to assist you in this matter, I suggest that you contact the local Soil Conservation Service Office at P. O. Box 546, Norwalk, OH 44857, for technical advice in correcting the problem.

Sincerely yours,

BERNARD C. HUGHES
Colonel, Corps of Engineers
District Engineer

Sloan_____
Koller_____
Baldi_____
Gilbert____
Liddell____
Walker_____
Hughes_____

CF:
NCBED-PS

APPENDIX B
TECHNICAL

BY RCN DATE 8/30 SUBJECT DESIGN WAVE AT VERMILION SHEET NO. 1 OF 5
CHKD. BY DATE JOB NO. 7707025

REFERENCES:

(1) REPORT ON GREAT LAKES OPEN COAST FLOOD LEVELS, (DETROIT DISTRICT, C of E, FEB. 1977)

(2) SHORE PROTECTION MANUAL (COASTAL ENGINEERING RESEARCH CENTER, 1973

(3) DESIGN WAVE INFORMATION FOR THE GREAT LAKES, REPORT NO. 1, LAKE ERIE [TR. H-76-1], (U.S. ARMY WATERWAYS EXPERIMENT STATION, VICKSBURG, MS. JAN, 1976)

A. DESIGN CRITERIA

Guidance from the North Central Division (NCD) ina. to the use of a 200-year recurrence event using a 10-year SWL and a 20-year deep water wave

1. 10-year SWL

FROM (1), Plate 4, Vermilion is at Reach T

∴ Design water level = 574.2 (IGLD) which is 5.6 feet above LWD. This represents the Average Monthly max level of the lake, plus the short-term fluctuation due to the 10-year storm.

2. 20-year storm wave

FROM (3), Tables E1 & E2 (applicable portions attached)

DIRECTION (ANGLE CLASS)	SIGNIFICANT WAVE HEIGHT FT.	PERIOD SEC.
W - NNW (3)	10.5	7.65
NNW - NNE (2)	11.2	7.76
NNE - NE (1)	11.2	7.86

20-5

TABLE OF EXTREMES ESTIMATES
GRID LOCATION 11, 7 LAT=41.57 LON=82.30 VERMILION OH
SHORELINE GRID POINT 7

WINTER
ANGLE CLASSES

	1	2	3	ALL
5	7.2(0.3)	8.9(0.5)	8.9(0.3)	10.0(0.5)
10	7.9(0.3)	9.8(0.6)	9.8(0.4)	11.0(0.6)
20	8.5(0.4)	11.2(0.8)	10.5(0.6)	11.9(0.8)
50	9.5(0.5)	12.5(0.9)	11.8(0.7)	13.1(1.0)
100	10.2(0.6)	13.4(1.1)	12.5(0.8)	14.0(1.1)

SPRING
ANGLE CLASSES

	1	2	3	ALL
5	3.3(0.6)	2.0(0.4)	4.3(0.4)	5.2(0.6)
10	4.6(0.7)	3.0(0.6)	5.2(0.5)	6.4(0.8)
20	5.9(0.9)	3.9(0.7)	6.2(0.7)	7.5(1.0)
50	7.9(1.1)	5.6(0.9)	7.5(0.8)	9.1(1.2)
100	9.2(1.3)	6.6(1.0)	8.5(0.9)	10.3(1.4)

SUMMER
ANGLE CLASSES

	1	2	3	ALL
5	4.3(1.4)	4.3(1.3)	4.3(0.9)	5.7(1.5)
10	4.9(1.8)	5.2(1.7)	5.2(1.2)	6.9(1.9)
20	5.9(2.3)	6.2(2.1)	6.2(1.5)	8.0(2.4)
50	7.5(2.9)	7.9(2.6)	7.5(1.8)	9.6(3.0)
100	8.9(3.3)	9.2(3.0)	8.5(2.1)	10.8(3.5)

FALL
ANGLE CLASSES

	1	2	3	ALL
5	7.2(0.8)	7.9(0.3)	7.9(0.4)	9.6(0.9)
10	9.2(1.1)	8.5(0.4)	8.9(0.5)	10.8(1.2)
20	11.2(1.4)	9.5(0.6)	9.8(0.6)	12.2(1.5)
50	14.1(1.7)	10.5(0.7)	10.8(0.8)	14.4(1.8)
100	16.1(2.0)	11.5(0.8)	11.8(0.9)	16.3(2.[illegible])

3 of 5

GRID LOCATION 11, 7 LAT=41.57 LON=82.30 VERMILION OH

GRID POINT NUMBER 7

SIGNIFICANT PERIOD BY ANGLE CLASS AND WAVE HEIGHT

WAVE HEIGHT (FT) ANGLE CLASS

WAVE HEIGHT (FT)	1	2	3
1	2.4	2.3	2.3
2	3.7	3.6	3.6
3	4.6	4.5	4.5
4	5.3	5.3	5.2
5	5.9	5.8	5.8
6	6.2	6.1	6.1
7	6.5	6.4	6.5
8	6.8	6.7	6.8
9	7.1	7.0	7.2
10	7.4	7.4	7.5
11	7.8	7.7	7.8
12	8.1	8.0	8.2
13	8.4	8.3	8.5
14	8.7	8.6	8.9
15	9.0	8.9	9.2
16	9.3	9.2	9.5
17	9.6	9.5	9.9
18	9.9	9.8	10.2
19	10.2	10.1	10.6
20	10.6	10.4	10.9
21	10.9	10.8	11.2
22	11.2	11.1	11.6
23	11.5	11.4	11.9
24	11.8	11.7	12.3
25	12.1	12.0	12.6

B. REFRACTION

For this preliminary design the refraction coefficient was assumed to be 1.0. During final design it will be necessary to refine this factor thru more detailed analysis

C DESIGN WAVE HEIGHT

Equations and Figures in this section refer to reference 2

T = wave period = 7.65 to 7.86 SEC

d_s depth of toe of structure ≈ 4.0 ft

bottom slope = m = 0.02 (1:50)

FOR T = 7.65 SEC

$d_s/gT^2 = 4.0/32.2(7.65)^2 = .0021$

FOR T = 7.86 SEC

$d_s/gT^2 = 4.0/32.2(7.86)^2 = .0020$

From FIG 7-4

$H_b/d_s = 0.96$

$H_b = 0.96(4) = 3.84$

$H_b/d_s = 0.97$

$H_b = 0.97(4) = 3.88$

USE $H_b = 3.88$ ft

D. BREAKING DEPTH

$H_b/gT^2 = 3.88/32.2(7.86)^2 = .0019$

FROM FIG 7-2

max = αH_b = (1.5(3.88) = 5.82 ft

min = $\beta(H_b)$ = (1.11)(3.88) = 4.30 ft

∴ STRUCTURES AT SHORELINE WILL BE JUST INSIDE BREAKERS.

H_o = deep water wave

H_o' = unrefracted deepwater wave

E UNREFRACTED DEEP WATER WAVE HEIGHT (H_o)

use t = 5.3 sec

$d/L_o = 4/5.12(5.3)^2 = .0781$

From table C-1

$H/H_o' = 1.143$

$H_o' = 3.39'$

H_b/gT^2 ~~.0019~~ .0043

From FIG. 7-5

H_b/H_o' 1.53

From EQN 7-5

$H_o = \frac{H_b}{K_R}(H_b/H_o')$

$H_o = 3.88/1.0(1.53) = 2.54'$

BY RCN DATE 8/30 SUBJECT DESIGN WAVE AT VERMILION SHEET NO. 5 OF 5
CHKD. BY DATE JOB NO. 7707005

F. ~~RUNUP~~

1. For Rubblemound Structure

$d_s/H_o' = 4/\cancel{2.54}\ 3.39 = \cancel{1.57}\ 1.18$

interpolate between FIG 7-10 & 7-11 (COT θ 1.5)

7-10 (d_s/H_o' = 0.8) 7-11 (d_s/H_o' 2.0)

$H_o/gT^2 = \cancel{2.54}\ 3.39/32.2(\cancel{7.06}\ 5.3)^2 = \cancel{.0013}\ .00375$ use 1 on 2 SS.

$R/H_o' = \cancel{4.5}\ 4.3$ $R/H_o' = \cancel{3.25}\ 3.5$

$\frac{1.57-.8}{2.0-.8} = \frac{x}{3.25-4.5} \rightarrow x = -.80$ $R/H_o' = 4.05$

$R/H_o' = 4.5 - .80 = 3.7'$ $R = \frac{4.05(3.39)1.166}{2} = 8.$

From FIG 7-13, k = 1.166

$R = 3.7(2.54)(1.166)/2 = 5.48'$

∴ CREST IS AT $574.2 + \cancel{5.48}\ 8 = \cancel{579.68}\ 582.2$ USE $\cancel{580.0}$ 582.0

2 For Gravity Wall.

$d_s/H_o' = \cancel{1.57}\ 1.18$ - say 1.5

$H_o/gT^2 = \cancel{.0013}\ .0038$

From FIG 7-14

$R/H_o' = \cancel{2.8}\ 2.4$

From Fig 7-13 k = 1.166

$R = \cancel{2.8}\ 2.4(2.54)(1.166) = \cancel{8.29}\ 9.48'$

∴ CREST IS AT $574.\cancel{6}\ 2 + \cancel{8.29}\ 9.5 = \cancel{582.89}\ 583.7$ say $\cancel{583.0}$ 584.0

Refers to plate 6

Page ___ of ___

Subject VERMILION OHIO - LINWOOD Park

Computation of STONE REVETMENT

Computed by LAK 9/27/77 Checked by ________ Date ________

QUANTITIES

ARMOR STONE	3,200 TON
UNDERLAYER STONE	1,400 TON
R.O.B SAND & GRAVEL	2,100 TON

R.O.B. SAND & GRAVEL

USE Lakeview State Park - Lorain, Ohio

Average bid price 4.88 + .84 add. haul = 5.72 USE

UNDERLAYER STONE 60# - 150#

Plant	=	2.00/TON
Labor	=	2.50/TON
Material	=	12.45/TON
TESTS	=	1.90/TON
		18.85 USE 19.00/TON

COVER STONE

Plant	=	2.90/TON
LaBor	=	3.00/TON
Material	=	13.10/TON
TESTS	=	2.80/TON
		21.80 USE 22.00/TON.

CONSTRUCTION OF RAMP AND HAUL ROAD __ $600

SUMMARY

MOB & Demob	= 500
Armor Stone 3,200 Ton @ 22.00	= 70,400
Underlayer Stone 1,400 Ton @ 19.00	= 26,600
R.O.B. Sand & Gravel 2,100 Ton @ 6.00	= 12,600
Construction of ramp & haul road L.S	= 600
	$110,700
Contingency 15% ±	16,800
TOTAL FIRST COST	$127,000

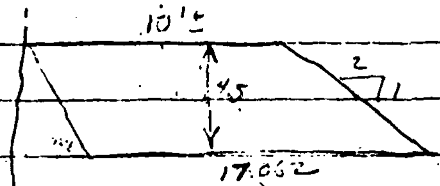
$a^2 + b^2 = c^2$

$4.5^2 + 9^2 = \sqrt{101.25} = 10.062$

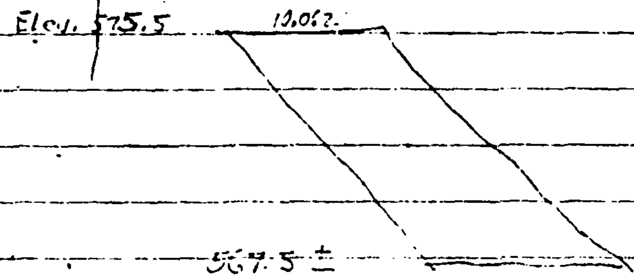
10.062

Volume of ARMOR

AREA of ARMOR Stone = Top = ELV. 575.5 to 580.0 =



$\frac{10 + 17.062}{2} \times 4.5 = 60.89^{SF}$



AREA = 10.062 × 8.0 = 80.496

Volume for 400 LF REACH

(60.89 + 80.496) 400 LF = 56,554.4 CF / 27 = 2,094.6 CY

Volume for Curved ENDS.

CENTROID of Cover Stone

AREA	DIST	moment
60.89 SF	7.97	485.2933
80.496	21.969	1768.4166
141.386 SF	15.94	2253.71

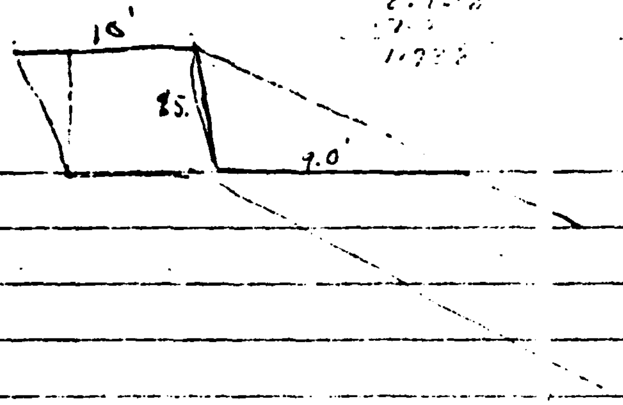
Vol of Curved END. $\frac{2\pi R}{2} \times$ AREA

3.1416 × 15.94 × 141.386 SF = 7,080.201 CF / 27 = 262.23 CY

Total Volume Cover Stone = 2356.83 CY

2356.83 CY × 1.36 = 3,205.29 USE 3,200 TON

3.1.2
8.938
7.
1.938



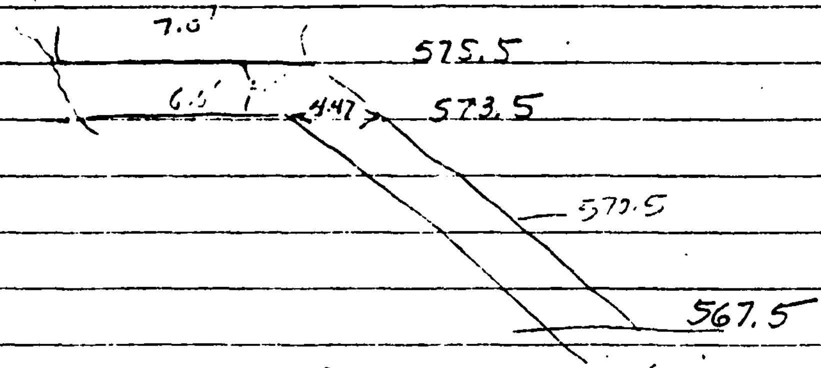
4.031
1.938

			Centroid	Moment
AREA △	.5×9.0'×4.50 =	20.25 ft²	13 LF	263.25
AREA □	8.062 LF × 4.5 =	36.279 ft²	5.969 LF	216.55
AREA ▽	.5×1.938×4.5 =	4.361	1.292	5.634
		60.89	$\boxed{7.97\text{ LF}}$	485.43

575.5
567

11.0
10.47

UNDERLAYER Stone.



AREA.	Dist	moment.
.5 X 2 X .53 = .53 $^{\square'}$	.353	0.187
6.47 X 2.0 = 12.94 $^{\square'}$	3.765	48.719
.5 X 2 X 4 = 4.00 $^{\square'}$	8.33	33.32
4.47 X 6.0' = 26.82	14.765	396.00
8.0 X 2.0 = 16.0 $^{\square'}$	34.062	544.96
60.29	$\boxed{16.97}$	1023.186

Volume of UNDERLAYER Stone 400 ^{LF} Reach.

60.29 $^{\square'}$ X 400 ^{LF} = 24,116 ^{SF} / 27 = 893.19 ^{CY}

Volume of UnderLay @ 2 ENDS, $\frac{2\pi R}{2}$ X AREA

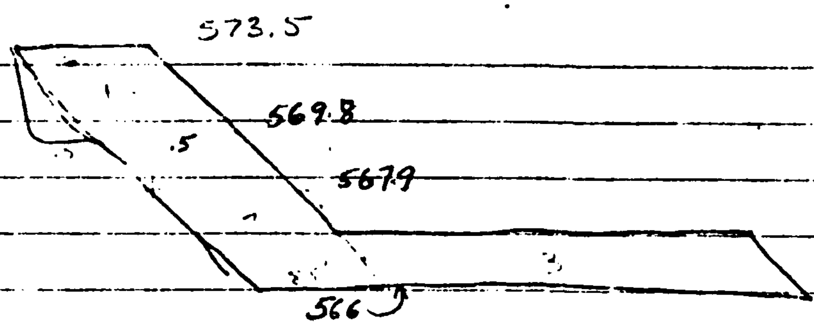
3.1416 X 16.97 X 60.29 = 3,214.24 ^{SF} = 119.05

Total UnderLayer = 1012.24 ^{CY}

1012.24 X 1.36 1417.14 ^{Ton} USE 1400 ^{Ton}

3

Volume R.O.B. Sand & Gravel



	AREA	DIST	MOMENT
	.5 x (6+10.0) 3.7 = 29.6 □'	5.5	162.8
	8.5 X 3.8 = 32.3 □'	12.95	418.29
	14.53 x 1.5 = 31.80 □'	26.77	583.59
	83.70 □'	$\boxed{13.91}$	1164.68

Volume For 400 LF Reach = 83.7 □' x 400 LF = 33480 CF = 1240 CY

Volume for Curved Ends.

πR x Area.

3.1416 X 13.91 X 83.70 = 3,657.66 CF = 135.47

1375.5

1375.5 CY x 1.512 Ton/CY = 2079.75 Use 2080 Ton

Refers to Plate 6

LINWOOD PARK
VERMILION, OH.

Computed by KK
14 Sept 77

$W = 7.5\ T$ Use $W_r = 155$ pcf

$$r = n K_\Delta \left(\frac{W}{W_r}\right)^{1/3} = 3 \times 1.15 \left(\frac{15000}{155}\right)^{1/3}$$ (968)

$= 3.45 \times 4.6 = 16$ ft $\pm$

$= 2.3 \times 4.6 = 10.5 \pm$

$r = 2.3 \times \left(\frac{1000}{155}\right)^{1/3} = 4.3 \pm$ (6.45)

El. 566 Lake bottom
MSL = El. 570
Setup = +3 + 570 = 573
− 566
7'
$0.8 \times 7 = 5.6'$

where H = '
$H = 5.6'$ Assume Breaking Wave

$$W = \frac{155\,(5.6)^3}{3.5 \times (1.49)^3\ 2} = \frac{27{,}220}{23.2} = 1173.$$ (3.31)

$= 0.587\ T$

Say 1200 lbs
0.6 T

Range 1000 − 2000 lbs

$$r = 3.45\left(\frac{1200}{155}\right)^{1/3} = 1.98 \times 3.45 = 6.8' \pm$$ (7.74)

$2.3 \times 1.98 = 4.5' \pm$; $1 \times 1.15 \times 1.98 = 2.3'$

Underlayer
$\frac{1000}{10} = 100$; $\frac{1000}{15} = 67$ lbs
$\frac{1200}{10} = 120$ lbs ; $\frac{1200}{15} = 80$ lbs
$\frac{2000}{10} = 200$ lbs $\frac{2000}{15} = 133$ lbs

Use 2' Thickness

$$7.5\ T = \frac{155\,(H)^3}{31.5\,(1.48)^3\,2} =$$

$$H^3 = \frac{15{,}000 \times 23.2}{155} = \frac{348{,}000}{155} = 2245$$

APPENDIX C
ECONOMIC

1. This is an analysis of probable emergency costs which would be incurred by the city of Vermilion if a rupture occurs in the Linwood Park sewer interceptor line.

2. The sewage interceptor line serves 300 homes, and it is assumed that the interruption would last for six weeks, or until an alternate line was laid. Using the 1974 average household size in Ohio of 3.06 persons, approximately 918 persons would be affected.

3. The initial response of the city would most likely be to bypass the broken interceptor with a three-inch fire hose and one pump. This would provide for continued service to homes "up-pipe" of the break. The cost of providing hose, pump, flares, lighting, and manpower for this action is estimated at $9,750.

4. The homes located on lateral sewage lines would require additional emergency facilities. It is estimated that three large portable sanitary facilities would be necessary. The rental fee of $1,500 for each portable latrine includes weekly clean up. The total cost of rental and manpower is estimated at $6,750.

5. The remaining needs of the homes on laterals (laundry, washing, etc.) would be met by pumping through a holding tank to a truck and transported for treatment. The cost of tank, truck, and driver ($460 per day), lighting, pump, and city supervision amounts to $20,700.

6. In addition, the city could expect to incur environmental clean up costs and health testing costs of a magnitude of $10,000.

7. Therefore, total emergency costs would approximate $47,200. If this occurred in project year one (1980), the average annual benefit to emergency costs avoided is $3,150.

8. The six week down time is based on conversations with the Vermilion City Engineer, Mr. Swanker, the Wellsville City Engineer, Mr. Faquer, and the New York State Department of Emergency Preparedness. Costs for equipment is based on discussions with Buffalo District General Engineering Section, the National Guard, and local suppliers of material.

9. The relocation cost of the sewage line was estimated at $30 per linear foot installed. This relocation cost of $102,500 would be added to land acquisition costs, and resetting the lateral intercepts. The total relocation cost would approximate $142,500.

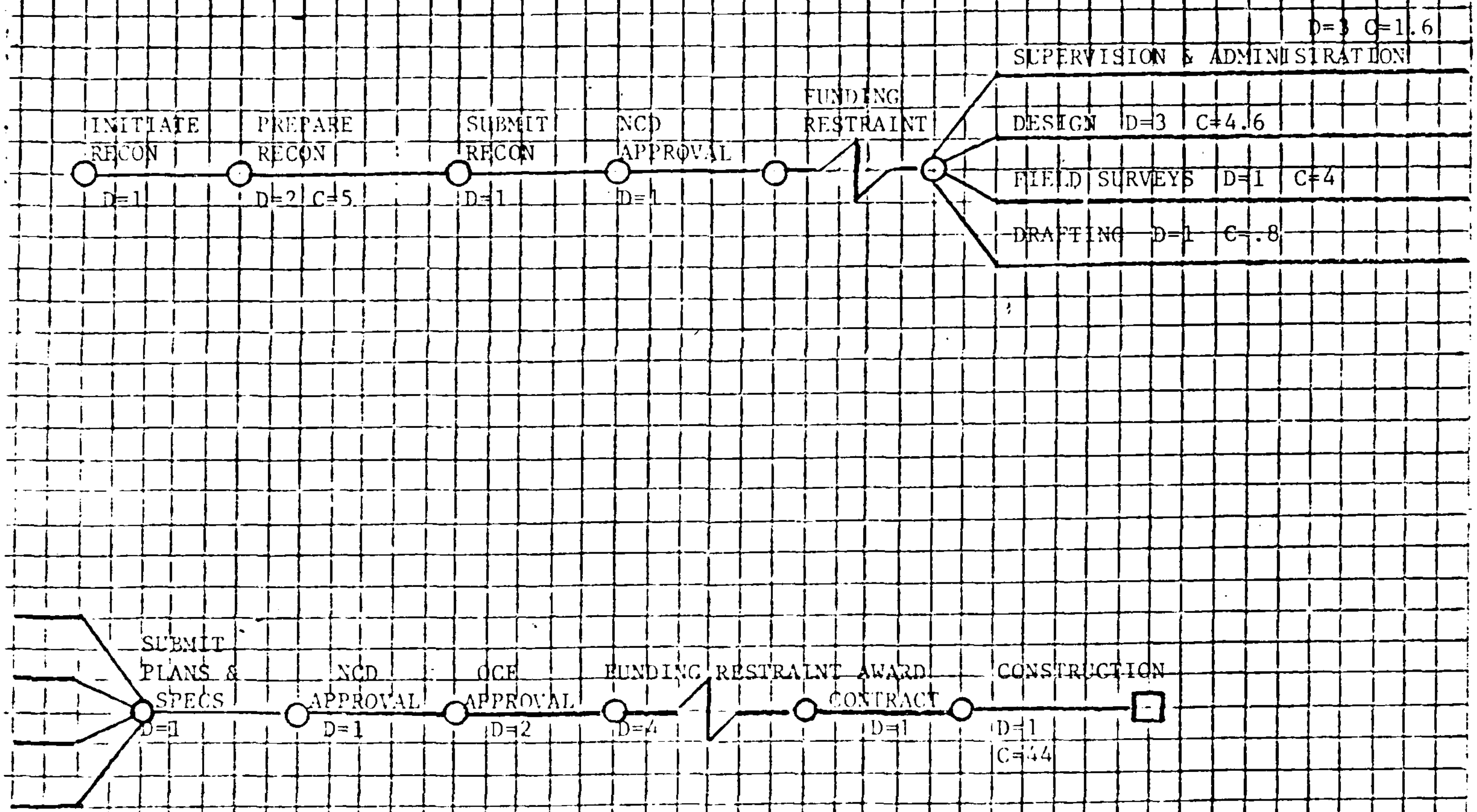
Page ___ of ___ pages.

Subject ___

Computation of ___

Computed by ___ Checked by ___ Date ___

SECTION 14 RECONNAISSANCE REPORT ON ELBERTA BEACH AND LINWOOD PARK, VERMILION, OHIO
LOCATION "A" ELBERTA BEACH



D = Duration
C = Cost, in thousands

Subject ____
Computation of ____
Computed by ____ Checked by ____ Date ____
Page ____ of ____ pages.

SECTION 14 RECONNAISSANCE REPORT FOR ELBERTA BEACH AND LINWOOD PARK, VERMILION, OHIO
LOCATION "B" LINWOOD PARK

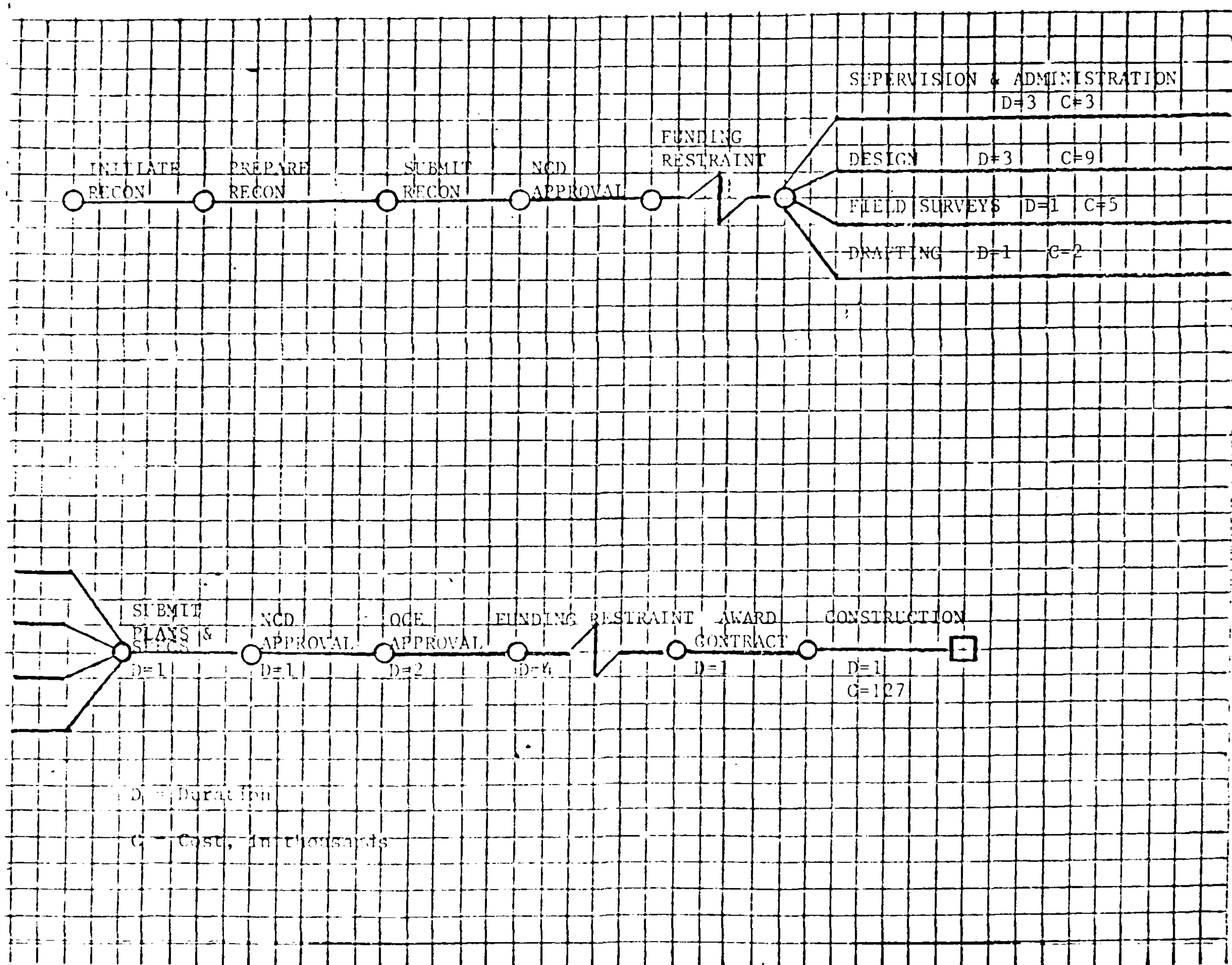


EXHIBIT C.4

OPERATION MAINTENANCE STATEMENT OF FINDINGS

STATEMENT OF FINDINGS

Operation and Maintenance
Vermilion Harbor, Erie County, OH

INTRODUCTION

I have reviewed and evaluated, in light of the overall public interest, documents and other information concerning the proposed action, as well as the stated views of other interested parties relative to the various practicable alternatives in accomplishing the operation and maintenance of Vermilion Harbor, Erie County, OH. The possible consequences of these alternatives have been analyzed with respect to environmental, social well-being, and economic impacts as well as engineering feasibility.

BACKGROUND

Authorization

The existing Federal project for commercial and recreational navigation at Vermilion Harbor was authorized by several River and Harbor Acts between 1836 and 1958, and was constructed in stages. Work authorized by the 1958 Act was completed in 1973. Harbor navigation project features include a lake approach channel (consisting of a 12-foot east lake approach channel and an 8-foot west lake approach channel) a 12-foot entrance channel, an 8-foot river channel, parallel east and west piers, and a detached breakwater. The harbor is maintained by the Buffalo District, Corps of Engineers.

Coordination and Public Involvement

Extensive coordination was maintained during the preparation, distribution, and review of the Draft Environmental Impact Statement (EIS) for the operation and maintenance of Vermilion Harbor. During the preparation of the Statement, six public land use planning agencies were contacted to determine the relationship of the proposed action to land use plans. No objections were expressed by responding agencies. In addition, the U. S. Department of the Interior, National Park Service, and the Ohio State Historic Preservation Officer were contacted to identify potential impacts of the proposed action on cultural resources. Neither agency indicated objections to the proposed action. The U. S. Department of the Interior, Fish and Wildlife Service and the Ohio Department of Natural Resources also were requested to identify significant fish and wildlife resources that should be considered in planning harbor maintenance activities. Responses from these agencies were used in developing a maintenance schedule that will result in the least possible disruption to significant fish spawning activities at Vermilion Harbor. The U. S. Environmental Protection Agency (USEPA),

Region V provided harbor sediment quality data that was used in determining environmentally acceptable methods for disposing of materials to be maintenance dredged. The Draft EIS was distributed for review and comment to Federal, State and local Government agencies and private organizations and individuals. Copies of the Draft EIS were also sent to local newspapers. A news release was issued stating the availability of the Draft EIS for review and comment by the general public. Comments on the Draft EIS from coordinating agencies, groups and individuals were carefully considered in evaluating the proposed action. Copies of all coordinating and commenting correspondence relative to the project are included in Appendices A and F of the Final EIS. Major issues related to harbor maintenance operations that were identified in the Draft EIS comments are as follows:

a. The U. S. Department of the Interior indicated that the Draft EIS proposal to dispose of restricted disposal sediments in the harbor's authorized Lake Erie disposal zone was environmentally unsound due to the reintroduction of potentially harmful constituents into the water column. This proposal was originally suggested in the July 1975 USEPA report to the Buffalo District on Vermilion Harbor sediment quality. The proposal included dredging and open-lake disposal of restricted disposal sediments, as classified by USEPA, and then dredging and open-lake disposal of sediments suitable for open-lake disposal in order to cover the moderately polluted materials with unpolluted materials. In view of the Interior Department's reservations about the proposal, and since no maintenance dredging is expected to be required in the entrance channel zone that USEPA designated as having restricted disposal sediments (due to river scouring of the zone), the proposal was eliminated as a feature of the maintenance project. If it is necessary to remove sediments from the restricted disposal zone, such materials will be disposed of in the Site 1 confined disposal facility at Huron Harbor, OH.

b. The alternative disposal practice of using unpolluted sediments as beach nourishment materials, instead of open-lake disposal of such sediments, was suggested by the U. S. Department of Commerce, the U. S. Department of the Interior, and several summer residents of the Linwood Park development. Long-term updrift disposal at beach areas east of the harbor would be much more costly than downdrift disposal at westward beaches. Furthermore, updrift disposal is not practical under existing conditions since nourishment materials would tend to be transported back into the navigation channels by the lake's east-to-west flowing littoral current. Downdrift (westward) disposal is economically feasible. However, the presence of the municipal water intake, a public beach, valuable fish habitat, and other environmental factors along the shoreline immediately west of the harbor are critical factors that must be evaluated with respect to each maintenance dredging operation. Therefore, should appropriate local interests express an interest in

in downdrift disposal for a particular operation, a separate environmental assessment of the proposal will be prepared and an appropriate course of action will be taken.

c. The Linwood Park Company and several summer residents of the Linwood Park development expressed oppositior to the Draft EIS proposal of a summer maintenance dredging schedule (any six-week period between 15 June and 1 October) due to the potential temporary, indirect effect of dredging activities on water quality at beach areas immediately adjacent to the harbor. In view of these local concerns and revised harbor fishery information from the Ohio Department of Natural Resources, the maintenance dredging schedule was changed to a six-week period between 15 September and 15 December. The fall maintenance schedule was coordinated with the Ohio Department of Natural Resources which had no objections to the fall period.

d. The alternative of removing the existing detached breakwater as a means of reducing shoaling in the outer harbor and the resulting need for maintenance dredging was suggested by the Ohio Environmental Protection Agency, the Sierra Club-Northeast Ohio Group, and several summer residents of the Linwood Park community. While the removal of the breakwater would achieve some reduction in outer harbor shoaling and the scope of maintenance dredging, this action would diminish or eliminate the ability of the total project to achieve its ongoing objectives (enhancement of commercial fishing, recreation, and navigation activities; provide a harbor of refuge) as well as reducing or negating qualitative benefits that the Vermilion Port Authority attributed to the presence of the structure in its November 1975 report to the Vermilion City Council. These benefits include a reduction of river surge, helping to control harbor water levels during north to northeast winds, providing a safer harbor entrance during storms, preventing windrowed ice from jamming at the pier heads, allowing ice to flow from the harbor during northeast winds, obligating the Corps to maintain the harbor up to the Liberty Avenue Bridge, and providing a protected sportfishing area behind the breakwater. In view of the long-term qualitative benefits that would be lost if the structure were removed, the alternative of removing the existing breakwater for the singular purpose of reducing the scope of maintenance activities is not presently justifiable.

In addition to comments on harbor maintenance activities, Draft EIS commenting letters from the Linwood Park Cottage Owners Association and summer residents of the Linwood Park development expressed concern over the potential effect of the detached breakwater on the local environment. One of the local interests' primary concerns is about

the potential relationship of the breakwater on shoreline erosion east of the harbor. On 6 October 1975, the District Engineer met with Mr. George W. Grossman, a resident of the Linwood Park community, in order to explain the Buffalo District's Section 111 Study of shoreline changes that have been attributed to the Federal navigation project. The study report, dated 21 January 1976, concludes that it is not now possible to differentiate between shoreline changes to the east that may be caused by high lake levels and those that may be attributed to the detached breakwater. The report recommends that a five-year monitoring program be undertaken to evaluate the effect of the detached breakwater, particularly during a period of more normal lake levels. A supplemental Section 111 Study will be prepared in 1981 based on the results of the five-year monitoring program.

Other concerns of the Linwood Park residents include the possible adverse effects of the detached breakwater on the public water supply, increased beach water pollution, ice formation in the harbor, increased ice jam flooding potential, increased flood potential, increased shoaling in the Federal and private lagoon navigation channels, land use changes and resultant changes in occupancy and property values, and increased navigation hazards. The Buffalo District will investigate these concerns in an Adverse Impact Study. The objectives of this study will be to review all previous reports on Corps programs at Vermilion, conduct an in-depth investigation of adverse effects that local interests have attributed to the presence of the detached breakwater in order to verify the validity of such effects, and identify alternative solutions or problems requiring additional study. The study report will be in compliance with the October 1975 Corps draft Environmental Guidelines to "review periodically the operation and maintenance of completed projects to assure that environmental quality exists consistent with project purposes." Appropriate recommendations for further action to resolve the community's concerns will be based on the study conclusions, which will be available in 1977.

There have been no public meetings or workshops conducted on the actual operation and maintenance of the harbor. On-going public involvement will be achieved in compliance with the regulation described in 33 CFR 209.145. Future maintenance dredging operations in Vermilion Harbor will be preceded by the issuance of a public notice as required by this regulation. The public notice will describe the proposed maintenance, and will be distributed to all potentially interested parties that may desire to comment on maintenance activities. In the event that the commenting parties identify any significant, adverse environmental impacts, the proposed work will be reevaluated and a course of action will be taken that is in the best overall interest of the public.

SELECTED PLAN

The selected plan of action is the operation and maintenance of Vermilion Harbor, which is described in detail in the Final EIS. The harbor's authorized navigation channels will be periodically surveyed with a survey launch to determine the amount of shoaling and sediment deposition in the authorized maintained channels. After the navigation channels have been surveyed, a dredge, and attendant scows and tugs, will be used to remove, transport, and dispose of channel bottom shoals and sediment deposits that have decreased channel depths below the authorized project depths. Maintenance dredging in the 120-foot east lake approach and lake entrance channels will be accomplished by one of the Buffalo District's smaller hopper dredges whenever it is feasible to do so. The U. S. Dredge HOFFMAN, which has a light draft of 9 feet, 8 inches and is based at Cleveland, will be used in these channels if it is available during the harbor's dredging season. Maintenance dredging in other portions of the harbor will be performed for the Corps by a private Contractor, using a shallow-draft dredge other than a hopper dredge, or by a Corps derrickboat equipped with a clamshell bucket. Based on the District's past experience in maintenance dredging at shallow-draft harbors similar to Vermilion, channel maintenance will probably be conducted with either a clamshell, dipper (or backhoe), or cutterhead dredge. These three dredge types are usually available for maintenance work on the Great Lakes and are suitable, to varying degrees, for efficient and economical work. Dredging operations will be accomplished only in those sectors of the navigation channels where significant sediment deposits have accumulated. Dredging operations will continue until the navigation channels have been cleared to authorized project depths. Upon completion of dredging, the harbor will be resounded to determine depths in the maintained channels. A final channel survey will be conducted with a sweep float to locate large navigation obstructions, such as stone from the harbor structures, that were not removed during dredging. Identified obstructions will be removed by a derrickboat and placed on a barge for transport from the project area. Routine maintenance dredging is expected to entail the removal of approximately 24,800 cubic yards of shoal material on a frequency of about once every three years. Each routine dredging operation will take about six weeks to complete, and will be conducted in the fall between about 15 September and 15 December whenever possible.

USEPA has classified bottom sediments in the lakeward section of the entrance channel and the lake approach channel suitable for open-lake disposal. Therefore, a total of approximately 20,000 cubic yards of dredgings that will be removed from these channels during each three-year routine operation will be disposed of in the harbor's authorized open-lake

dump zone in Lake Erie. USEPA has classified sediments in the river channel unsuitable for open-lake disposal. Approximately 4,800 cubic yards of dredgings that will be removed from this channel during each routine operation will be deposited in the Huron Harbor Site 1 diked disposal facility. USEPA has classified sediments in the inner section of the entrance channel as suitable for restricted open-lake disposal. The restricted disposal zone is usually kept free of shoals by the natural scouring action of the Vermilion River. Therefore, no maintenance is expected to be required in this zone, and no restricted disposal sediments are expected to require removal and disposal. However, if shoaling does occur and it is necessary to dredge restricted disposal sediments, such materials will be deposited in the Huron Harbor Site 1 diked disposal facility. A Final Environmental Impact Statement for Huron Site 1 was filed with the Council on Environmental Quality on 19 November 1973.

The harbor piers and detached breakwater are periodically inspected to determine the need for repair work. The need for repair results from structural damage or failure, usually caused by wave and ice action. A derrickboat, barge and tug vessel will be used to accomplish structural repair and maintenance work. Structural maintenance will be performed as needed, and will be accomplished during the summer months of the year.

The selected plan for the operation and maintenance of Vermilion includes several operational features that have been developed to minimize potentially adverse effects of maintenance activities on the natural and human environments. For example, the removal, transport, and disposal of harbor dredgings will be controlled to minimize the impacts of these operations on water quality and aquatic habitat in affected areas. The 15 September through 15 December dredging period will avoid interference with peak activity seasons for recreational boating, swimming at adjacent lakeshore beaches, and significant local fish spawning activities. Environmental protection features of the selected plan are described in detail in the Final EIS.

ALTERNATIVES

Eight other operation and maintenance alternatives were considered:

No Action

This alternative would result in the termination of navigation channel and structural maintenance activities at Vermilion Harbor. Although

this alternative would eliminate temporary adverse ecological effects of maintenance activities, the impact of this course of action would be to initially restrict, and eventually prohibit, navigation in and out of the harbor. This would have a most significant adverse effect on harbor-related recreation and associated local and regional employment and business at Vermilion.

Maintaining Alternative Channel Dimensions

The scope of maintenance dredging at Vermilion Harbor could be reduced by dredging the authorized channels to lesser depths or widths. Such operations would be technically feasible to accomplish and, depending on the alternative dimensions considered, would probably reduce maintenance costs due to a reduction in materials dredged. Since less material would be removed, short-term adverse effects of dredging on water quality, aquatic ecology, and harbor recreation and related businesses would be reduced to a level commensurate with reduced dredging time and area. However, any reduction in authorized channel dimensions would seriously affect the harbor's operational viability for safe navigation by small craft, which would have long-term adverse effects on employment, businesses, service and retail sales, public revenues, and other factors indirectly related to recreational boating.

Alternative Dredging Schedules

Summer, early winter, and early spring dredging periods were considered as alternative three-year dredging schedules. Dredging during any of these periods is technically feasible. Costs for summer dredging would be about equal to those for the selected fall dredging period, while costs for the other two periods would be substantially higher due to contingencies for inclement weather and related hazardous navigation conditions. Early spring dredging would generally result in the same environmental impacts associated with the selected period, while early winter operations would result in the least disruption of seasonal environmental factors. The feasibility of early spring and early winter dredging is highly questionable due to the likelihood of inclement weather and ice formation. Summer operations would adversely affect all harbor-related recreational and business activities during peak activity seasons, and is opposed by local interests as previously described. Dredging schedules of shorter duration could be implemented if the frequency of dredging was increased to annual operations. However, annual dredging would involve mobilization and demobilization costs three times greater than dredging with a frequency of once every three years. Furthermore, environmental effects that can be expected

to occur regardless of dredging season, duration, or frequency (such as turbidity and disruption of benthic habitat) would occur more often if dredging was conducted annually.

Land Disposal

Materials removed from Vermilion Harbor during maintenance dredging could be deposited in abandoned strip mines, quarries, or sand and gravel pits or used for agricultural purposes. The cost of using dredgings for these purposes is generally prohibitive due to the equipment and operational costs that would be incurred by transporting dredged material over extensive land distances. An upland site used to contain new work dredgings in 1973 has been filled, graded, seeded, and planted with trees and is not available for further disposal operations. Two other upland disposal sites in the Vermilion vicinity have been rejected due to their location adjacent to a streambed and the potential leaching problems that could result from their use. Therefore, at this time, there are no known viable on-land disposal sites in the Vermilion area.

Use of Unpolluted Dredged Material for Beach Nourishment

The Corps of Engineers has authority to place unpolluted dredge materials on beach areas if the cost of this action does not exceed the cost associated with open-lake disposal, or if local interests will bear any additional costs associated with this action. Beach nourishment disposal may be technically and economically feasible to accomplish using the harbor's unpolluted dredgings (about 20,000 cubic yards per routine operation) from the lake approach and entrance channels. As previously discussed, long-term updrift disposal at beach areas east of the harbor is neither economical nor practical under existing conditions due to the tendency for updrift materials to be littorally transported back into the navigation channels. Deposition in downdrift, littoral areas west of the harbor is more practical since nourishment materials would be littorally transported away from the harbor. Downdrift disposal would have short-term localized, adverse effects on aquatic ecology but would have long-term, beneficial effects on shoreline erosion and beach areas. There have been no specific requests from appropriate downdrift beach interests regarding investigation of the use of unpolluted dredgings from Vermilion Harbor as downdrift beach nourishment material. However, should appropriate local interests express an interest in the implementation of a beach nourishment program using suitable maintenance dredgings, the Corps will analyze the engineering and economic feasibility of the specific proposal, and a separate environmental assessment of the action will be prepared.

Modification of the Harbor Structures

Structural modifications of the Vermilion Harbor breakwater and east pier were suggested by local interests as means of reducing the scope of maintenance. In its November 1975 report, the Vermilion Port Authority suggested storing additional stone atop the east pier in order to trap some of the sand that is presently transported over the pier by wind and wave action (particularly during northeast and east storms) at the beach area east of the pier. While this alternative would probably result in some short-term reduction in shoaling in the outer section of the entrance channel, it would eventually result in shoaling in the east lake approach channel and along the entire length of the entrance channel as the build-up east of the pier initially moved around the added stone and finally overtopped it. In the long run, this would increase maintenance dredging requirements. As previously discussed, the alternative of removing the detached breakwater in order to reduce outer harbor shoaling was suggested by State and local interests. In addition, the Vermilion Port Authority's report suggested removing a submerged section of the breakwater to permit a more direct flow of river discharge into the lake. Either of these breakwater modifications would be expected to reduce outer harbor shoaling and the scope of channel maintenance activities. However, as previously discussed, modification or removal of the structure would diminish or eliminate the ability of the total project to achieve its ongoing objectives (enhancement of commercial fishing, recreation, and navigation activities; provide a harbor of refuge) as well as reducing or negating the benefits that the Vermilion Port Authority attributed to the presence of the structure. In view of the long-term qualitative benefits that would be lost, the alternative of modifying the existing breakwater for the singular purpose of reducing the scope of maintenance activities is not presently justifiable.

Control of Erosion

Control of erosion from sources in the harbor's watershed, along the harbor shoreline, and along the lakeshore would reduce sediment loading. Erosion control would involve programs to improve agricultural practices, construction regulations, and land use management. The construction of lakeshore groins east of the harbor was suggested in the Vermilion Port Authority's November 1975 report and in Draft EIS comments from local interests. While the aforementioned practices would be expected to achieve some reductions in harbor shoaling, they would not completely eliminate the need for future dredging in Vermilion Harbor. Establishment of erosion control measures would require a lengthy period of time to implement and would be costly. This alternative is not within the

authority under which the operation and maintenance of the harbor is performed.

Control of Sediment Pollutants

Treatment of sediments by chemical means to allow for the open-lake dumping of dredged material, while technically feasible for small amounts of material, is economically unrealistic at this time for the quantities of polluted sediment to be removed from Vermilion Harbor. A long-range goal to control pollutants would be the implementation of pollution abatement measures throughout the Vermilion region to reduce the addition of toxic and nutritive constituents to harbor sediments. Such measures are required by both Federal and State laws and could include upgrading of sewage treatment plants and use of settling basins for stormwater discharges. These long-term programs are the responsibility of local municipalities and industries and are beyond the authority under which the operation and maintenance of Vermilion Harbor is accomplished.

EVALUATION

In evaluating the selected plan, the following points are considered pertinent:

Environmental Considerations

The presence of maintenance vessels in Vermilion Harbor will result in temporary localized adverse effects on aquatic ecology, water quality, and air quality. Maintenance dredging will be conducted in a manner that minimizes such environmental effects by confining dredging to shoaled portions of authorized, essential navigation channels and preventing overflow spillage of dredgings between the dredging area and disposal sites. Fall dredging will eliminate potential interference with late-spring and summer fish spawning in the harbor area. Open-lake disposal of unpolluted dredgings will result in some temporary turbidity and siltation of aquatic habitat. Disposal operations of unpolluted materials will be controlled to minimize adverse environmental effects related to the open-lake disposal of unpolluted materials. Polluted sediments will be disposed of in the Huron Harbor Site 1 diked disposal facility in order to eliminate adverse water quality effects associated with the open-lake disposal of such materials.

Social Well-Being

Operation and maintenance of Vermilion Harbor will insure the continued use of the harbor for the more than 10,000 commercial fishing vessels

and recreational boats that use the harbor annually. Adverse social impacts associated with dredging, such as interference with boating, are short-term and infrequent. Fall dredging will eliminate interferences during the local peak seasons for recreational navigation and swimming activities at adjacent beach areas. Social benefits accrue because of the importance of harbor-generated business, employment, and public revenues to communities and regions economically linked to Vermilion Harbor. The estimated average annual wholesale value of fish expected to be landed at Vermilion Harbor over the next three years is $650,000. The operator of the Vermilion City Water Plant will be specifically notified of proposed maintenance operations so that mitigative plant procedures can be formulated and operational as the situation may warrant. No cultural resources will be impacted by maintenance activities.

Engineering Considerations

The use of various types of maintenance equipment at Vermilion Harbor was considered in terms of practicability, cost effectiveness, and availability. The shallow-draft dredge and support vessels were found to be the most favorable plant for channel maintenance, and the derrick-boat and attendant vessels the best suited for structural maintenance. A small Corps hopper dredge is suitable for operations in the 12-foot channels. Maintenance dredging and structural repairs will be performed only when it is necessary to achieve authorized project depths or to restore the physical integrity of the existing harbor piers and detached breakwater.

Economic Considerations

Maintenance and repair costs are dependent upon the nature of shoaling in navigation channels, the extent of structural repairs, and funding constraints; therefore, costs can be expected to vary from year to year. Future routine maintenance dredging will cost approximately $188,000 per operation, or $62,700 annually. These cost estimates can be expected to vary with the extent and nature of future channel shoaling. Future structural repair costs will also vary with the condition of the harbor structures.

CONCLUSION

In conclusion, I find that the determination to operate and maintain Vermilion Harbor in the manner described is based upon a thorough analysis and evaluation of the various practicable alternatives to the proposed action. Wherever adverse effects are found to be involved,

they cannot be avoided by following reasonable alternative courses of action which would achieve the purposes specified by the Congress. Accordingly, it is my decision that the public interest would best be served by the operation and periodic maintenance of Vermilion Harbor, Erie County, OH.

Date: 25 March 1976

BERNARD C. HUGHES
Colonel, Corps of Engineers
District Engineer

STATEMENT OF FINDINGS

Operation and Maintenance
Vermilion Harbor, Erie County, OH

I concur with the preceding Statement of Findings.

26 Apr 76
DATE

ROBERT L. MOORE
Brigadier General, USA
Division Engineer

I concur with the preceding Statement of Findings.

22 Jun 1976
DATE

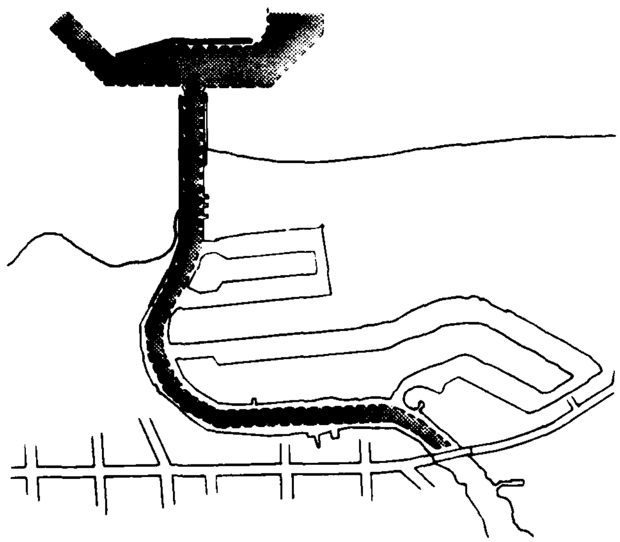
DRAKE WILSON
Brigadier General, USA
Deputy Director of Civil Works

VERMILION HARBOR, OHIO

DETAILED PROJECT REPORT ON SECTION 111

SHORE EROSION STUDY

STAGE 3 DOCUMENTATION



APPENDIX D

PUBLIC INVOLVEMENT

U.S. ARMY CORPS OF ENGINEERS
BUFFALO DISTRICT
1776 NIAGARA STREET
BUFFALO, NEW YORK 14207

September 1982

INFORMATION MEETING ON
VERMILION HARBOR BREAKWATER IMPACT STUDIES
SUMMARY MINUTES

An information meeting, presided by Colonel George P. Johnson, Buffalo District Engineer, was held on 23 June 1982 in Vermilion at the Vermilion High School Auditorium located on Sanford Street, Vermilion, Ohio. The meeting came to order at 8 o'clock p.m. with a slide presentation by Colonel Johnson, which lasted about thirty minutes. After outlining the steps along which the meeting was conducted, the public was offered the opportunity to comment on them. Mr. Thomas Corrigan, an attorney representing Mr. Grossman and other residents of Linwood Park took the opportunity to question the Colonel on what kind of meeting it was. He wanted to know if it was a public hearing as requested by his clients under 33 CFR 327; and if not, why was it denied? The Colonel repeated time and again that the meeting was a public meeting conducted in the same manner as all other Corps public meetings; and that whether one calls it a public meeting or hearing, the public has the same opportunity to discuss the issues, make statements, and ask questions which are always taken into consideration when final recommendations are made. The lawyer seemed not satisfied with the answer and asked again if his clients were denied a hearing. After a few minutes of discussion, the Colonel said I'll have my counsel respond to your inquiry on 33 CFR 327 because of its legal aspect. The lawyer advised his clients not to make any statements either pro or con. Colonel Johnson advised the public that their legal rights were not denied and that they could make any statement or ask any questions on the studies if so desired. He held up the reports and said "We are in a draft report stage, and if anything new came out of this meeting, whether you call it an informational hearing or a public meeting or hearing, I still would be in a position to change that decision. So if there is any thought out there that because we are calling it an informational meeting rather than a public meeting or some other type of hearing, if you think for some reason that your rights are somehow denied, let me guarantee you that is not the case." At that point, the Colonel proceeded with his slide presentation which was a convincing presentation. It revolved around the history of the project development going back to the 1800's. The Colonel discussed the natrual shore processes involving beach erosion and accretion both before and after the breakwater construction. He concluded that the Beach system had accreted as evidenced by the return of Nakomis Beach. He cautioned though that the Beach will recede at times when high lake levels and high wind conditions prevail.

On the question of ice jam flooding he repeated the fact that wind rowing (mounds of ice) at the river mouth, before breakwater construction had stopped since construction of that breakwater. It now takes place lakeward of the breakwater, which lessens the potential for flooding. He clarified his recommendation, to higher headquarters, to deepen the entrance channel to allow the larger Coast Guard vessels to enter the harbor for ice breaking operations. He said, "My proposal to deepen the entrance channel is not, and I repeat, not a measure to mitigate ice jam flooding due to breakwater construction. Rather, it is in response to a changed condition at Vermilion Harbor, namely, the introduction of larger Coast Guard vessels that the Coast Guard tells us require

a greater depth of water for safe and efficient operation . . . the Corps would not even submit the report to Congress for construction authorization unless a local sponsor requests the project and has indicated its intent to provide the items of local cooperation."

In his speech, the Colonel pointed out that the studies were conducted for the most part by an unbiased Consulting firm of national reputation at a cost of half a million dollars to the American taxpayers. He exhibited the names, along with their professional credentials, of most of the people who participated in the studies.

Immediately following the speech, the floor was open for comments. Most attendees refrained from making statements as they were instructed by their counsel. However, one of them did make a statement and inquired about a Corps Panel or a neutral body other than the Corps to hold this type of a meeting? The Colonel said no; this is not Corps policy.

The question-and-answer session dominated the meeting. Several questions were asked and answered. They revolved around the same general complaints the Corps had investigated for about 8 years. The typical concern was beach erosion, beach pollution and ice jam flooding, all caused by the presence of the breakwater. One of the participants described these concerns as a huge public outcry. The Colonel refuted that by reading the statistics compiled by the District on the public review of the reports. He said, no negative comments were received from any of the Federal, state, city or local agencies in Vermilion. Of more than 300 private citizens reached, only 0.09 mostly Linwood Park cottage owners requested a hearing; and all the letters were consistent letters. So, said the Colonel, "It is not a public outcry. It is small compared to those who have expressed an interest or shown any interest in this particular project." The meeting adjourned at 10:30 p.m.

Attendees (corps)

Colonel George P. Johnson, Corps of Engineers
Donald M. Liddell, Corps of Engineers
John Zorich, Corps of Engineers
Wiener Cadet, Corps of Engineers
Denton R. Clark, Corps of Engineers
Ross Fredenburg, Corps of Engineers

(over)

LIST OF ATTENDEES

Col. George P. Johnson, Corps of Engineers
Donald M. Liddell, Corps of Engineers
John Zorich, Corps of Engineers
Wiener Cadet, Corps of Engineers
Denton R. Clark, Corps of Engineers
H. Ross Fredenburg, Corps of Engineers
Diane Milete, Office of Congressman Pease
Mary Ann Sloan, Office of Congressman Pease
Grace and Walter Waite
Mrs. Charles A. Waite
John R. Keith
Mr. and Mrs. John J. Horbaly
Grace Woods
Dorothy Jean Lee
Helen Bell
Arline P. Ford
Anne R. Turner
Frank J. Lee
Martha H. Keith
Ronald Guy Hetche
Ruth E. Partington
Nancy Rothman
Mark Magnotto
Thomas J. Long
Martha K. Long
Mark and Jackie Williams
Kathryn N. Kress
Pamela G. Magnotto
Bruce A. Chamberlin
Toni Krause
Charles C. Hupp
Billie Jean Holub
Roberta Berns
Ray J. Krause
Thomas G. Williams
Frank J. Holub
G. L. Roth
Nancy A. Symons
Clarence W. Turner
Donald Parsons
Frank J. Holub
Dr. Oliver M. Hackett
Milan Doering
Mr. and Mrs. Tom S. Williams
Dr. George E. Keidel
Robert W. Eckley

E. Valerie Jenkins
Judith Lee Alexander
Albert D. Gilchrist
E. M. Latteman
Monica Ilas
Ann Peters
David T. Berns
Kenneth R. Kress
Phyllis Grossman
Bonnie J. Roberts
Naomi G. Harding
Barbara L. Scott
Daniel L. Roberts
Robert J. Scott
Mr. and Mrs. Donald E. Geiger
Charley Geiger
Mr. and Mrs. Claude H. Chisler
Barbara Coy
Herbert L. Cooper
Douglas A. Fox
Sally J. Fox
Margaret H. Adams
Charles G. Adams
Hobart A. Johnson
Maxine Kutza-Karl
Mr. And Mrs. Warren Prestel
Suzanne L. Krueck
Carol J. Koppin-Willett
Linda K. Krueck
Lois H. Cooper
Mrs. Charles Green
Francis C. Dreyer
W. B. Dreyer
William E. Dearth
J. W. Rutledge
Lois K. Rutledge
Mr. and Mrs. G. R. Thompson
Ruth E. Peterka
Herbert Woods
Julius A. Moes
George W. Grossman
F. F. Peterka
Jane Hetche

DEPARTMENT OF THE ARMY
BUFFALO DISTRICT, CORPS OF ENGINEERS
1776 NIAGARA STREET
BUFFALO, NEW YORK 14207

NCBPD-WB

4 June 1982

Dear Participant:

As per the attached Public Notice, the Buffalo District invites you to an Informational Meeting on the Vermilion Breakwater Impact Studies on 23 June 1982 at 8:00 PM at the Vermilion High School.

Sincerely,

GEORGE P. JOHNSON
Colonel, Corps of Engineers
District Engineer

US Army Corps
of Engineers
Buffalo District

Public Notice

VERMILION HARBOR INFORMATIONAL MEETING

This is to announce that the Buffalo District will conduct an Informational Meeting to discuss the results of the recently completed studies on the impacts of the Vermilion Harbor Project on the adjacent areas. Based on the comments the District Engineer received from the public review of the Vermilion reports, it became apparent that many of the respondees, particularly those in Linwood Park, may have misinterpreted the study results specifically with respect to ice-jam flooding and shore erosion. The purpose of this meeting is to further clarify these aspects of the study.

Who should attend

Anyone interested in the US Army Corps of Engineers studies on the impact of the detached breakwater in Vermilion Harbor, Ohio

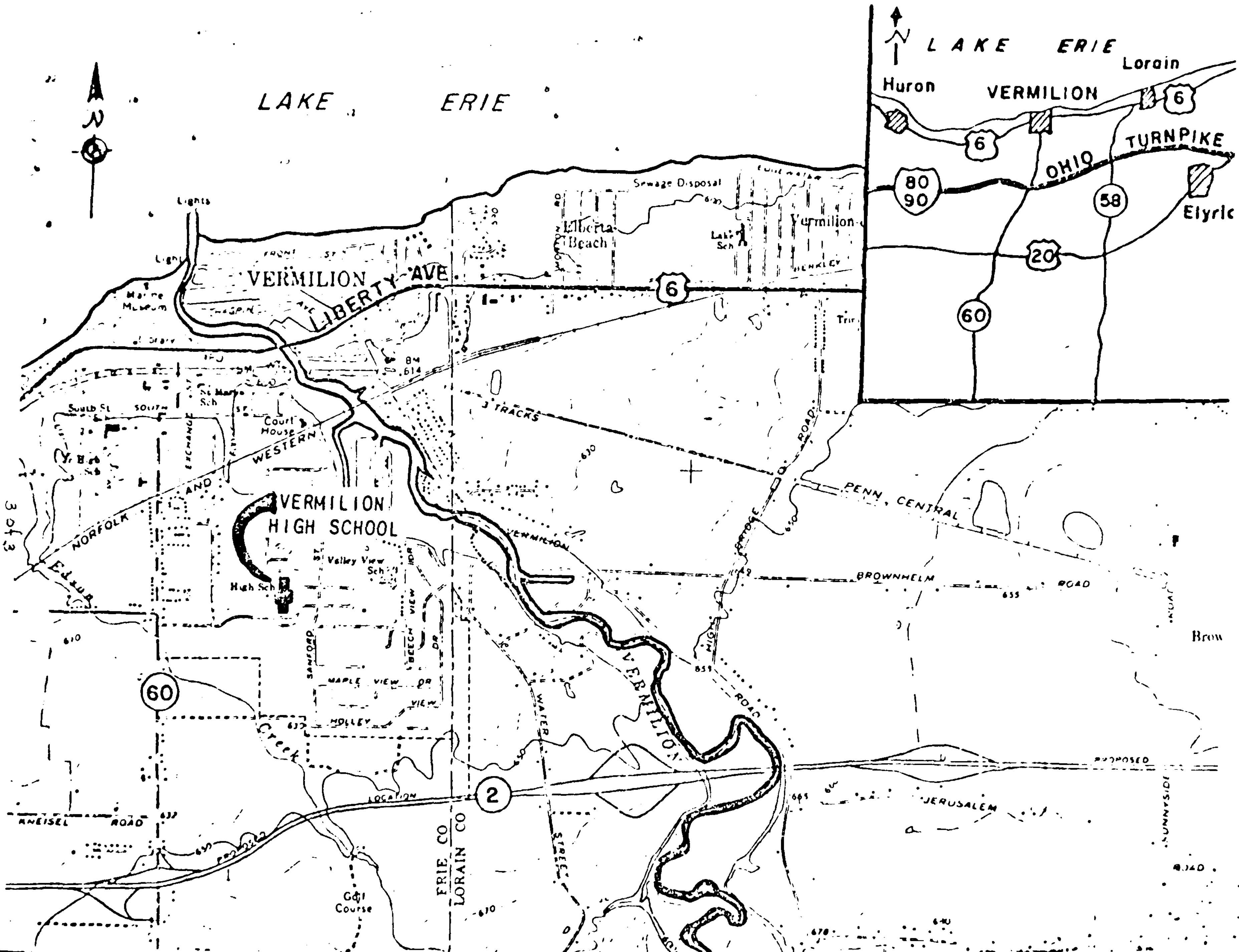
Where and when

Vermilion High School
1250 Sanford Street
Vermilion, Ohio
(See map on reverse side for meeting location)

Wednesday, 23 June 1982
8:00 PM

For additional information contact: Wiener Cadet, Project Manager, at (716) 876-5454, extension 2276

S. Army Corps of Engineers, Buffalo District, 1776 Niagara Street, Buffalo, New York 1420?


LAKE ERIE
Huron
VERMILION
Loraín
6
OHIO TURNPIKE
80 90
58
Elyrıc
20
60
LAKE ERIE
Lights
Marine Museum
VERMILION
LIBERTY AVE
6
Sewage Disposal
Elberta Beach
Vermilion
Court House
WESTERN
NORFOLK AND WESTERN
3 TRACKS
PENN CENTRAL
BRIDGE ROAD
BROWNHELM ROAD
VERMILION HIGH SCHOOL
High Sch
Valley View Sch
SANFORD
BEECH VIEW DR
MAPLE VIEW DR
HOLLEY
Creek
60
2
LOCATION
KNEISEL ROAD
Golf Course
ERIE CO
LORAIN CO
WATER STREET
VERMILION
HIGH ROAD
PROPOSED
JERUSALEM
SUNNYSIDE
Brow
3 of 3

News...

from the Corps of Engineers, Buffalo District

1776 Niagara Street
Buffalo, NY 14207

FOR INFORMATION CONTACT
Jessie Whitefield
AC716 876-5454

FOR IMMEDIATE RELEASE: June 8, 1982

The Vermilion Breakwater Impact Studies by the Corps of Engineers will be the subject of an Informational Meeting to be held on Wednesday, June 23rd at 8:00PM in the auditorium of the Vermilion High School at 1250 Sanford Street.

Comments received by the District Engineer from public review of the recently completed studies on the impacts of the detached breakwater in Vermilion Harbor indicate that many of the respondees, particularly those in Linwood Park, may have misinterpreted the study conclusions concerning ice-jam flooding and shore erosion. The purpose of the meeting is to clarify these aspects of the study.

-30-

NCBED-DC 23 September 1981

Honorable Donald J. Pease
House of Representatives
Washington, DC 20515

Dear Mr. Pease:

I am pleased to respond to your letter of 1 September 1981 regarding Mr. Alex Angney's inquiry as to the current status of our studies on the impacts of the breakwater structure at the entrance to Vermilion Harbor.

I have received all the programmed technical reports which have been prepared by recognized independent consultant firms to evaluate each alleged area of impact. These reports are undergoing final assessment by my engineering staff in preparation for development of a Stage 3 Detailed Project Report (DPR). The Draft DPR will be completed late this fall and will formally transmit my recommendations to North Central Division for review and approval. After that we will solicit public review and comment.

The potential impacts associated with ice-jam flooding and shoreline damages have received detailed investigation, most recently by Tetra Tech, Inc. Review of these reports, particularly the most recent one, "Summary Evaluation Historical Shore and Bluff Changes, East of Vermilion Harbor, Ohio," indicate that the physical evidence does not prove a long-term adverse impact to Lagoons, Linwood, or Nakomis Beaches associated with the breakwater. The East Linwood Park and Nakomis Beaches have experienced significant accretion in the last few years resulting in a return of the pre-1970 beaches associated with the pre-breakwater, low-water period. Tetra Tech's summary interpretation is ". . . the period 1977 to 1980 indicate the fluctuation and trend of the shoreline in the three segments are comparable to that shown for the pre-breakwater periods. This further indicates that the influence of the breakwater on the fluctuations and trends of the shoreline east of the East Pier have been minimal since 1977."

Obviously, I will not base my recommendation on a single quotation but intend to fully incorporate all the professional evaluations and measured documentation available to develop a recommendation which is fair to the concerns of Mr. Angney and others in Vermilion and also honestly interprets the Federal Government's moral and financial responsibilities.

NCBED-DC
Honorable Donald J. Pease

I appreciate your concern and will keep you and your office informed as to the disposition of this issue.

Sincerely,

GEORGE P. JOHNSON
Colonel, Corp of Engineers
District Engineer

Pope ______
Clark ______
Foley ______
Cadet ______
Zorich ______
Gilbert ______
Hallock/Liddell ______
Creeden ______
Johnson ______

CF:
CDR, USACE (DAEN-CWA-D) w/incmg corresp.
NCDED
NCBED-PW
NCBCO-CL
NCBED-DC
XO
PAO
Honorable Donald J. Pease
1936 Cooper-Foster Park Road
Lorain, OH 44053

DON J. PEASE
13TH DISTRICT, OHIO

1127 LONGWORTH BUILDING
WASHINGTON, D.C. 20515
(202) 225-3401

COMMITTEE ON
WAYS AND MEANS

SUBCOMMITTEE ON TRADE
SUBCOMMITTEE ON
PUBLIC ASSISTANCE AND
UNEMPLOYMENT COMPENSATION

Congress of the United States
House of Representatives
Washington, D.C. 20515

ADMINISTRATIVE ASSISTANT:
BILL GOOLD

DISTRICT OFFICE:
ROBERT RULLI
1936 COOPER-FOSTER PARK ROAD, LORAIN
(216) 282-5003

PART-TIME OFFICES:
MRS. DOROTHY LITMAN
157 COLUMBUS AVENUE, SANDUSKY
(419) 625-7193

COUNTY ADMINISTRATION BUILDING MEDINA
(216) 725-6120

MUNICIPAL BUILDING, BARBERTON
(216) 848-1001

September 1, 1981

Colonel George Johnson
District Engineer
Army Corps of Engineers - Buffalo District
1776 Niagara Street
Buffalo, New York 14207

Dear Cclonel Johnson:

Enclosed is a copy of a recent letter I received from a constituent of mine, Mr. Alex Angney of Vermilion, Ohio. I am very interested in receiving a report on where matters stand with respect to rectifying the long-standing problems attending the breakwater at the entrance of Vermilion harbor.

I appreciate your cooperation and assistance in this important concern to me and many of my Vermilion constituents.

Sincerely yours,

Don J. Pease

DON J. PEASE
Member of Congress

DJP/glm

Encl.

A. A. ANGNEY
P. O. Box 82
Vermilion, OH 44089

Mailed from Congressman Pease's Office on September 9th.
— Reg File —

8-5-81

Dear Congressman Pease,

On May 21, 1981, the Vermilion City Council passed resolution number 79R-8 calling for the removal/modification of the breakwater at the Vermilion harbour entrance. As President of Council at that time, and a life long resident I am curious where we stand on this concern.

The US Army Corps of Engineers will be the first to admit they have never made a mistake. I'm sure you are aware of the efforts of George Grossman regarding the wall. I've heard little of his efforts, recently. I feel he's run the legal and political gauntlets and perhaps given up.

Nevertheless, many residents are still concerned, but God you can only talk so much. Please advise.

Very Truly Yours
Al Angney

C: GEORGE GROSSMAN

NCDRE-B

23 January 1981

Subject: *Report of termination of instrument.*

~~THRU:~~

FOR RECORD PURPOSES ONLY

~~TO:~~

You are hereby notified of the termination of the following-described instrument in accordance with the terms thereof:

(*a*) *Symbol number:* DACA22-5-79-1002

(*b*) *Name and address of* ~~grantee~~ grantor:
Vermilion Laggons, Inc.
5419 Park Drive
Vermilion, OH 44089

(*c*) *Kind of instrument:* Inlease

(*d*) *Location:* Vermilion Harbor, Ohio

(*e*) *Effective date of termination:* 20 May 1979

(*f*) *How terminated:* By its terms

(*g*) *Compliance with conditions of instrument as to vacation, removal of property, and restoration of premises:* By letter dated 6 June 1979, grantor advised that no damages were suffered as a result of the Government's use of the property. No formal release will be obtained.

FOR THE DISTRICT ENGINEER:

Inclosure
Statement of Damages

CARY B. PATERSON
Chief, Real Estate Office
U.S. Army Engineer District, Buffalo

Distribution as checked

☒ Division Engineer, Real Estate ATTN: NCDRE-M
☒ Other
NCDRE-B
NCBCO
NCBED
Buffalo District Reading File

ENG FORM 1 OCT 75 1368 EDITION OF APR 67 IS OBSOLETE. (ER 405-1-800)

STATEMENT OF DAMAGES

June 6 1979
(Date)

District Engineer
U.S. Army Engineer District, Buffalo N.Y.
(Address) 1776 Niagara St.

In re: Vermilion Harbor Ohio Sand Pumping Demonstration
(Project)
Lease #DACW22-5-79-1002

Dear Sir:

In regard to your recent Sand Pumping Demonstration on my land in The Village of Vermilion, Erie County, State of Ohio, I wish to advise you that:

[X] I have not suffered damages. In my opinion, the Sand Pumping Demonstration did not cause damage to the above property.

[ ] I have suffered damages and request that settlement be made therefor. The damages are more particularly described as follows:

Robert Lichorer
(Witness)
464 Parkside
Bay Village, Ohio 44140
(Address)

Calvin C Blackman, Trustee
Vermilion Lagoons Inc

5419 Park Drive
Vermilion, Ohio 44089

NCDRE-B

23 January 1981

Subject: *Report of termination of instrument.*

~~THRU:~~

~~TO:~~ FOR RECORD PURPOSES ONLY

You are hereby notified of the termination of the following-described instrument in accordance with the terms thereof:

(*a*) *Symbol number:* DACW22-5-79-1003

(*b*) *Name and address of* ~~grantee:~~ **grantor:**
Linwood Park Company
1070 Wilbert Road
Lakewood, OH 44107

(*c*) *Kind of instrument:* **Inlease**

(*d*) *Location:* **Vermilion Harbor, Ohio**

(*e*) *Effective date of termination:* 20 **May** 1979

(*f*) *How terminated:* **By its terms**

(*g*) *Compliance with conditions of instrument as to vacation, removal of property, and restoration of premises:* **By letter dated 13 June 1979, grantor advised that no damages were suffered as a result of the Government's use of the property. No formal release will be obtained.**

FOR THE DISTRICT ENGINEER:

Inclosure
Statement of Damages

GARY B. PATERSON
Chief, Real Estate Office
U.S.A rmy Engineer District, Buffalo

Distribution as checked

☒ Division Engineer, Real Estate, ATTN: NCDRE-M
☒ Cy furn
NCBED
NCBCO
NCDRE-B
Buffalo District Reading File

ENG FORM 1 OCT 75 1368 EDITION OF APR 67 IS OBSOLETE. (ER 405-1-800)

STATEMENT OF DAMAGES

6/13/79
(Date)

District Engineer
U.S. Army Engineer District, Buffalo N.Y.
(Address) 1776 Niagara St.

In re: Vermilion Harbor Ohio Sand Pumping Demonstration
(Project)
Lease #DACW22-5-79-1003

Dear Sir:

In regard to your recent Sand Pumping Demonstration on my land in The Village of Vermilion, Erie County, State of Ohio, I wish to advise you that:

[x] I have not suffered damages. In my opnion, the Sand Pumping Demonstration did not cause damage to the above property.

[ ] I have suffered damages and request that settlement be made therefor. The damages are more particularly described as follows:

J2C
(Witness)

RSC, President
Linwood Park Co.

1070 Wilbert Road
Lakewood, Ohio 44107
(Address)

NCDRE-B 23 January 1981

Subject: *Report of termination of instrument.*

XXXXXX:

FOR RECORD PURPOSES ONLY

XXXX

You are hereby notified of the termination of the following-described instrument in accordance with the terms thereof:

(a) *Symbol number:* DACW22-5-79-1001

(b) *Name and address of* XXXXX *grantor:*
City of Vermilion
P.O. Box 317
Vermilion, OH 44089

(c) *Kind of instrument:* Inlease

(d) *Location:* Vermilion Harbor, Ohio

(e) *Effective date of termination:* 20 May 1979

(f) *How terminated:* By its terms

(g) *Compliance with conditions of instrument as to vacation, removal of property, and restoration of premises:* By letter dated 5 July 1979, grantor advised that no damages were suffered as a result of the Government use of the property. No formal release will be obtained.

FOR THE DISTRICT ENGINEER:

Inclosure

Statement of Damages

GARY B. PATERSON
Chief, Real Estate Office
U.S. Army Engineer District, Buffalo

Distribution as checked

X [illegible] Engineer [illegible]; ATTN: NCDRE-M
X [illegible]
NCBED
NCBCO
NCDRE-B
Buffalo District Reading File

ENG FORM 1 OCT 75 1368 EDITION OF APR 67 IS OBSOLETE. (ER 405-1-800)

STATEMENT OF DAMAGES

July 5, 1979
(Date)

District Engineer
U.S. Army Engineer District,
1776 Niagara St.
Buffalo, NY 14207

In re: Vermilion Harbor Ohio Sand Pumping Demonstration
(Project)
Lease # DACW22-5-79-1001

Dear Sir:

In regard to your recent Sand Pumping Demonstration on my land in The city of Vermilion, Erie County, State of Ohio, I wish to advise you that:

✓ I have not suffered damages. In my opinion, the Sand Pumping Demonstration did not cause damage to the above property.

I have suffered damages and request that settlement be made therefor. The damages are more particularly described as follows:

Elizabeth Ann Pallas
(Witness)
Crystal Ann Eitner

Jim Olson, Mayor
City of Vermilion
PO Box 317
Vermilion Ohio 44089

United States Department of the Interior

FISH AND WILDLIFE SERVICE

IN REPLY REFER TO:

East Lansing Area Office
Manly Miles Building, Room 202
1405 South Harrison Road
East Lansing, Michigan 48823

SEP 29 1983

Colonel George P. Johnson
District Engineer
U. S. Army Engineer District
Buffalo
1776 Niagara Street
Buffalo, New York 14207

Dear Colonel Johnson:

This is the U. S. Fish and Wildlife Service's preliminary Fish and Wildlife Coordination Act Report on the fisheries impacts associated with your proposal to relocate the Vermilion Harbor open-lake disposal area. This report has been prepared under the authority of and in accordance with provisions of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.) and in compliance with the intent of the National Environmental Policy Act of 1969.

The Buffalo District Corps of Engineers is undertaking this disposal area relocation investigation at the request of local residents. Local residents are concerned that beaches in the vicinity of Vermilion Harbor are being or have been depleted of sand and believe that if the disposal area was relocated, lake currents would return some of the disposed sand to the beach areas.

The relocated disposal area would be located approximately one mile to one and one-half miles east or 1,500 to 2,000 feet west of Vermilion Harbor in water depths of five to fifteen feet. At these two locations water depths of five to fifteen feet occur within 600 to 1,500 feet of the shoreline.

The bottom material in these proposed disposal areas consists of sand and gravel with some rock-rubble. This nearshore zone is a very productive area and is used as spawning, nursery, feeding and wintering areas by a variety of fish species. Fish species that could be expected to use the area during some stage of their life cycle include; smallmouth bass, white crappie, yellow perch, channel catfish, rock bass, green sunfish and various darters and minnows. The degree of utilization by any of these species would be dependent on the water depths, bottom type, and time of year; i.e. some species may use the area for spawning while other species would use it as nursery or feeding areas at different times of the year. The proposed disposal areas also contain a variety of phytoplankton, zooplankton and benthic organisms. The specific species and population densities would need to be determined by an intensive site specific survey of the proposed disposal areas.

Many factors regarding the dredged material, the disposal operation, and the disposal sites must be considered in evaluating the fisheries impacts of relocating the Vermilion disposal site. Factors to be considered may be grouped under the following basic categories: physical, biological, and chemical. The physical, biological, and chemical characteristics of the dredged material could be readily determined by analysis of the sediments. The physical, biological and chemical characteristics of the proposed disposal sites and the disposal operation could be determined, but at a considerable monetary commitment.

Many studies have been conducted regarding the affects on fisheries of open-water disposal of dredged material. Many of the studies have concluded that some of the effects are temporary (for example, turbidity) while other effects are permanent (smothering benthos or fish eggs, a change in bottom composition, etc.).

The impacts of disposal operations on fish can range from none to fatal, depending on the species, life stage, and characteristics of the disposed material. An adult fish in a disposal area may avoid all impacts during the actual disposal operation by moving from the area. But adult fish may be adversely affected if they later return to the disposal area to feed on contaminated organisms or injest contaminated material. Also, adult fish may be affected if their preferred food organisms are covered with dredged material and they must seek another source of the preferred organism or find an alternative food source. Adult or juvenile fish may be adversely affected by the disposal operation if suspended particles of disposed material damage gill filaments. Eggs or larval fish in the disposal area could be destroyed or injured by the disposal operation. Fish species could also be impacted by the loss of feeding or spawning areas outside of the disposal area due to lake currents which move the disposed material.

An excellent source of information on the effects of open-water disposal impacts is contained in the Corps of Engineers,' Dredged Materials Research Program's Technical Report D-77-42, Aquatic Disposal Field Investigations, Ashtabula River Disposal Site, Ohio, Evaluative Summary and Appendices A-C. Since these investigations were site specific, conclusions drawn may not be applicable to the Vermilion open-water disposal area.

General information available on the western Lake Erie fish and wildlife resources in the proposed disposal area leads us to believe that major detrimental impacts could occur if dredged material was deposited in the proposed disposal areas. If you anticipate further study of this proposed relocation, the following site specific data must be obtained in order to accurately predict the impacts on the fisheries of relocating the Vermilion disposal area. Data that must be obtained includes but is not limited to the following: (1) an accurate description of the location of the proposed disposal areas, (2) a chemical, biological and physical analysis of the dredged material, (3) a four-season fishery survey of the proposed disposal area, (4) a detailed survey of phytoplankton, zooplankton and benthic organisms in the proposed disposal areas, and (5) a description of the nearshore water currents and littoral drift.

We look forward to continued coordination regarding the proposed relocation of the Vermilion disposal area.

Sincerely yours,

Raymond G. Oberson

Acting Area Manager

Vermilion Port Authority

CITY HALL
736 MAIN STREET
VERMILION, OHIO 44089
AREA CODE 216/967-5517

May 1, 1980

Donald M. Liddell
Chief, Engineering Division
Department of The Army
Buffalo District, Corps of Engineers
1776 Niagara Street
Buffalo, New York, 14207

Dear Mr. Liddell:

Thank you for providing copies of Tetra Tech's Draft Report of April 1980 to each member of the Vermilion Port Authority.

You requested our comments by 25 April 1980, however, some of us did not receive our copies until as late as 22 April 1980. Even though we called a special executive work session on 24 April, two to three days did not allow enough time to properly review this report in a manner which it deserved.

It would appear to us that Alternative No. 3 would be our choice only because of the benefit/cost factor. This is not to say other alternatives might have been a better choice over the long term had we had more time for study.

One alternative the report did not cover that might be worth investigating is the beach nourishment method used at Cedar Point a few years ago. Specially shaped solid concrete units were laid end to end parallel to the beach which trapped sand within a short period of time resulting in a wide sandy beach. This could provide a buffer zone between the water line and the bluffs. These units were manufactured by Campbell Construction Company of North Ridgeville Ohio.

Thank you again for your consideration. We apologize for not meeting your deadline. If, in the future, it would be possible to allow us at lease two weeks lead time, perhaps our review and comments would be more meaningful.

If we can be of any assistance in any way, please contact us. The present mambers of the Vermilion Port Authority are interested and eager to do all we can to cooperate with the Corps of Engineers and see Vermilion's harbor and shore line improved.

Sincerely,

Warren Wood

Warren L. Wood, Chairman
Vermilion Port Authority

[illegible]
[illegible]
[illegible]

WLW:bz

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DEPARTMENT OF TRANSPORTATION
UNITED STATES COAST GUARD

Address reply to:
COMMANDER(osr)
Ninth Coast Guard District
1240 East 9th St.
Cleveland, Ohio 44199
Phone: 216-522-3981

16150
1 April 1980

Colonel George P. Johnson
District Engineer, Buffalo District
Corps of Engineers
1776 Niagara Street
Buffalo, New York 14207

Dear Colonel Johnson:

My staff has reviewed Tetra Tech's Draft Report of Special Impact Study on Ice Jam Flooding in Vermilion Harbor, Ohio (Feb 80). We offer the following comments with regard to the icebreaking proposals within the Study:

a. A 75-foot channel is extremely narrow for transit by an icebreaker with a 38-foot beam, especially when unmarked by buoys. At the least, provision for a range may be required as an aid to safe navigation of the channel.

b. The control in backing of a 140-foot class icebreaker is poor without a well-defined stationary track through which to back. Again, the 75-foot channel would present a problem under most ice conditions.

c. From an icebreaking standpoint, a breach detached breakwater (Alternative 2) would have advantages (e.g., a straight-in approach, and probably less need to maneuver shoreward of the breakwater). However, the effectiveness of that alternative in preventing flooding would not appear any better than that of 2B.

d. As has always been the case, wind, temperature, snow cover, river volume, and the level of Lake Erie will be factors in the success of each individual icebreaking attempt.

e. We concur with the Study's suggestion that the City of Vermilion upgrade its local flood relief capabilities to whatever degree possible.

Thank you for the opportunity to comment on the Study.

Sincerely,

R. A. Bauman

R. A. BAUMAN
Captain, U. S. Coast Guard
Chief, Operations Division
By direction of Commander,
Ninth Coast Guard District

April 10, 1979
OHIO DEPARTMENT OF NATURAL RESOURCES
PUBLIC HEARING STATEMENT

Demonstration Project for Artificial Transport of Sand
From Lagoons Beach to Linwood Beach, Vermilion, Ohio
(Buffalo District, Corps of Engineers)

Good Evening Col. Brown, members of the Buffalo District, Corps of Engineers staff, public officials, and ladies and gentlemen.

The Department of Natural Resources is in concurrence with the proposed demonstration of artificial sand transport at Vermilion, Ohio. It should be noted that this demonstration project is not in conformance with the general policies of the state regarding utilization of materials within the littoral (or near shore) zone of Lake Erie. However, the anticipated result ~~effect~~ of this demonstration project is to determine the effects of artificial sand transport to compensate for natural littoral processes that would occur in the absence of man-induced changes in the littoral system.

The proposed action by the Buffalo District, Corps of Engineers will help to answer questions of importance to the Department of Natural Resources which may have implications elsewhere in the Lake Erie coastal zone. A careful monitoring of this project should supply data of great value to regulatory and resource management agencies, and will improve the planning and design of future water resource projects.

The Department will continue to coordinate with the Corps of Engineers regarding specific aspects of the proposed demonstration project.

Thank you.

153 Pickwick Drive
Northfield, Ohio, 44067
April 9, 1979

Col. Daniel Ludwig
District Engineer
Department of the Army
Buffalo District, Corps of Engineers
1776 Niagara Street
Buffalo, New York 14207

Dear Col. Ludwig:

This letter is comment for the Public Hearing to be held at Vermilion, Ohio on April 10, 1979.

The Linwood Park Cottage Owners Association, representing the cottage owners in Linwood Park, is strongly in favor of the proposed demonstration project for artificial transport of sand from Lagoons Beach and the East navigation channel to Linwood Beach. We support the methods suggested and are in agreement with the time schedule proposed. We do not expect any significant adverse environmental effects - only improvements to the environment!

We certainly appreciate the positive vote on this suggestion by the members of the Lagoons Association and their understanding of the need for cooperation between community groups.

I think it's important to point out that the people using Linwood Park Beach are not the only ones who will benefit from this Demonstration Project. It's been apparent for several years now that the massive accumulation of sand at the East pier causes the East navigation channel to be filled with sand. Removing this sand accumulation and placing it updrift will provide the benefits of: reduced need for dredging, a deeper East channel, an easier access of the Coast Guard ice breaker into Vermilion Harbor, and, therefore, less likelihood of ice-jam flooding.

We request that you consider placing part of the sand that is moved directly against the bluff overlooking the proposed nourishment area. This bluff was badly eroded two years ago when there was no sand in this area. Placing sand against this bluff will prevent further sliding, loss of trees and grass cover, and can provide protection for the sewer line that is buried in the edge of the bluff.

In summary, we appreciate that the Corps of Engineers recognizes this erosion problem and is willing, at considerable expense, to propose corrective measures. If the Demonstration Project is successful, we would support a regular program of sand transport in order to stabilize this beach.

Yours very truly,

David T. Berns

David T. Berns, Vice-president
Linwood Park Cottage Owners Assn.

THE LINWOOD PARK CO.

ESTABLISHED 1883

ON LAKE ERIE

VERMILION, OHIO 44089

April 5, 1979

Buffalo District, Corps of Engineers
1776 Niagara St.
Buffalo, New York 14207

Reference: Demonstration Project for Artificial Transport of Sand from Lagoons Beach to Linwood Beach.

Gentlemen:

There follows our comment on the Environmental Assessment dated March 1979 covering the above reference:

1. Assuming the temporary easement to be requested by the Corps of Engineers is acceptable, particularly with reference to personal injury liability, we support the project and will give it our full cooperation.

2. In our meeting with the Corps' representatives on February 20,1979 we asked whether the sand dredged and transported to our beach would be free of pollutants which might be dangerous or offensive to persons using the beach. We felt the answer given at that time was not entirely responsive to our question. Further, there is no reference to this potential problem in the Environmental Assessment.

3. What assurances can you give that the sand transported will be acceptable from the standpoint of harmful pollutants? We believe the sand deposited in the primary and secondary borrow areas was relatively pollution free when deposited. There is concern, however, about what pollutants may have been added to the sources after they were deposited. For example, what may have been the effect of back-wash of river discharge?

We respectfully suggest that reasonable testing of the sources prior to transport is in order if such testing has not already been done.

Very truly yours,

The Linwood Park Co.

R.S. Cheheyl

R.S. Cheheyl
President

FILE COPY
Checked by
Filed by

March 15, 1979

Dept. of the Army
Buffalo Dist., Corps of Engineers
1776 Niagara St.
Buffalo, NY 14207

Subject: Section III Alternative 2 Proposal, Hydraulically Pumping Sand From East Pier Fillet at Lagoons Beach to Linwood Beach at Vermilion, OH.

Dear Colonel Ludwig:

The Vermilion Lagoon Trustees have finally received the necessary approvals for this demonstration project, but we are advised by our legal council to have you submit an appropriate easement. You know exactly what is required and we can review this with our council and obtain quicker approval.

As discussed in the meeting at Linwood Park on February 20, 1979, and discussed with your Project Manager - Mike Wojnas, there are a number of items of concern.

1. Project completion to be before May 21, 1979, since Decoration Day weekend May 25th.the Lagoons hold an annual beach party.
2. Dredging between 8:00 AM and 8:00 PM.
3. Clean up of beach areas and maintenance of equipment.
4. Safety measures to be adhered to.
5. Sand contours of beach to be maintained or altered per approval of trustees.

We will look forward to receiving your easement agreement.

Very truly,

Calvin C Blackman

Calvin C. Blackman
Vermilion Lagoons Trustee - Chairman

CCB/jw

NCBED-PW

DISPOSITION FORM

For use of this form, see AR 340-15, the proponent agency is TAGCEN.

REFERENCE OR OFFICE SYMBOL	SUBJECT
NCBDE	Meeting at Vermilion, OH, 11 Oct 78, to Discuss Sections 14 and 111 Studies

TO	FROM	DATE	CMT 1
Memo for Record	NCBDE	17 Oct 78 COL Ludwig/jf/2200	

1. I met at the Town Hall on 11 Oct 78 at the invitation of Mayor Jim L. Odom to discuss alternative courses of action regarding erosion in the vicinity of Vermilion Harbor. In addition to members of the City Council, representatives of the Linwood Park Company, Linwood Park Cottage Owners Association, Vermilion Port Authority, and Ohio Department of Natural Resources were present. Accompanying me were Ron Guido and Mike Wojnas.

2. I indicated that the purpose of this meeting was to obtain acceptability of local and interested officials concerning tentative recommendations that I have made regarding our Sections 14 and Section 111 Studies at Vermilion. Since I need to forward recommendations on both of these studies to NCD, I specified that I need to be aware of local acceptance or nonacceptance of the various alternatives available.

3. The first item that we discussed concerned placing of dredged material upon Nakomis and Linwood Beaches. We have approximately 6,000 c.y. to be dredged this Fall which I indicated I would not place upon those beaches for two reasons; first, the material contains a majority of silt and clay which is unsuitable for beach replenishment, and secondly, it would be impossible for me to transport that material due to restrictions in existing regulations. I also pointed out that there is insufficient material available to have any reasonable impact upon the beaches. After some discussion the group accepted my decision.

4. I then brought up the subject of the Section 14 Studies. The Linwood Park Cottage Owners Association definitely stated that they would have nothing to do with the stone revetment. We closed discussion on this topic when I advised Mayor Odom that I would like a letter of intent from him as local assurer on this project. He indicated that he would inform me whether he would provide assurances for both the Alberta Beach and Linwood Park portions, or for just the Alberta Beach portion.

5. We discussed the various options that have been presented in our Syllabus for the Section 111 Study. I made it clear that any of the structural alternatives would require participation of local interests since the costs could not be totally borne by the Federal Government. Since representatives of the Lagoons Association were not present, I was unable to determine if that organization would consider our Alternative 2 which envisions the pumping of sand from Lagoons Beach to Nakomis-Linwood Beaches. At the end of the discussion on this topic, I summarized that those present would be agreeable to either our Alternative 2 or Alternative 3

should be 4. [illegible]

Inclosure 2

George W. Grossman
17125 Amber Drive
Cleveland, Ohio 44111

August 31, 1978

STATEMENT TO PUBLIC MEETING
ON VERMILION HARBOR

Colonel Daniel D. Ludwig
U. S. Army Corps of Engineers
Buffalo District
1776 Niagara St.
Buffalo, New York 14207

Dear Colonel Ludwig:

The Vermilion Harbor breakwater has been a very poor investment for the public because (1) the benefits predicted for the project have always been greatly overestimated, and (2) the social and environmental costs resulting from the breakwater were not considered prior to construction.

Projected Benefits from Modifying Vermilion Harbor

The first public hearing on the recent changes to Vermilion Harbor was held 33 years ago on May 3, 1945. At that meeting, the mayor stated that the village was unable to contribute anything for changing the harbor. Many of the local citizens were unwilling to pay even a portion of the cost because they did not envision any benefits from changing the harbor. The events of the past five years have proved that this initial local evaluation was accurate.

In 1958, when Congress authorized the breakwater, the Corps estimated annual benefits totaling $107,700 as follows:

50% Net Profit on increased fish catch	$10,100
Savings on losses of fish nets	9,900
Benefits to recreational boaters	77,700
Harbor of refuge	10,000

Congress was told that 58% of this $107,700 in benefits were "general benefits to be realized by the nation as a whole", when any effect is obviously purely local. It is of interest that the benefits from "the increased ease and convenience afforded existing navigation" were classified as intangible and not given a monetary value.

In 1971, with plans and cost estimates completed, the Corps stated that the 1956 project costs of $853,000 had inflated 106% to $1,757,000. Consequently, the benefits were also inflated from $107,700 to $229,000 at March, 1971 price levels. The validity of the $229,000 benefit estimate was questioned by the Office of the Chief of Engineers on 20 January, 1972. Thereupon, the Buffalo District revised their estimate of tangible benefits on 16 May, 1972 to the following:

Commercial fishing benefits	$ 23,200
Recreational boating benefits	442,700
Harbor of refuge benefits	10,000
Total Annual Benefits	$475,900

All of these benefit estimates lack credibility. Even the Corps has used the $229,000 annual benefit estimate in the recently issued Section 111 syllabus in lieu of the $475,900 estimate. Apparently, the public, the Corps, and Congress do not expect an accurate accounting when constructing public works with U. S. Treasury funds. They look only for justification of the project. However, the Vermilion breakwater is now assessing us with very real and tangible costs to restore eroded beaches, control pollution, and minimize flood damage. It is time to assess benefits in a way that the public can accept them as credible.

The Actual Benefits to Navigation from the Breakwater

1. Commercial Fishing Tangible Benefits - None. There are no increased fish catches or nets to be saved because of the breakwater. Commercial fishermen had a perfect safety record at the harbor entrance for about 60 years prior to the breakwater. Lake Erie commercial fishermen are skilled and weather-wise. They listen to the weather radio and make harbor before lake conditions become hazardous.

2. Recreational Boating Tangible Benefits - None. Vermilion recreational boaters, for the most part, are also skilled and knowledgeable about the hazards of Lake Erie weather. With just 2' waves on the lake, there are few recreational power boaters to be seen. It is uncomfortable to be out there pitching and rolling. We do see foolhardy boaters hesitate behind the breakwater as they examine oncoming storms before heading home. They frequently will take the gamble unless the Coast Guard herds them back into harbor. Reckless boaters are not aided by a breakwater.

Vermilion docks were filled to capacity long before the breakwater was constructed. Visiting boats were frequently required to raft off because visitor dock space has always been limited. Any claims that the breakwater increases harbor usage and sells more boats, dock rentals, gas or marine supplies are difficult to sustain.

3. Harbor of Refuge Tangible Benefits - None. Vermilion was a harbor of refuge for over 135 years prior to the breakwater. As a summer squall would approach, there was a very orderly and efficient exodus from the lake. Boats swung into line and came straight into harbor. A harbor of refuge is generally considered to be a new harbor like Hammond Bay Harbor on Lake Huron.

4. Intangible Navigation Benefits - Some. Some boaters can claim "the increased ease and convenience afforded existing navigation". However, even this convenience has its price. Stanley Consultants, on page 198 of the impact study, notes increased harbor congestion, restricted visibility, and other navigation problems caused by the breakwater. Stanley also says that these problems "do not constitute hazards to navigation for the knowledgeable, well-prepared, cautious boater." That's all we have ever needed for safety in Vermilion Harbor - knowledgeable, well-prepared, cautious boaters.

Erroneous "Benefit" Accounting in the Section 111 Syllabus

The Corps has employed four tables and several pages of discussion in the Section 111 syllabus to support a new claim that the breakwater has created unanticipated benefits of $39,200 a year by increasing the total size of Vermilion beaches. Even a cursory audit of this very detailed claim of benefits shows that such a claim is outrageous.

1. Lagoons Beach is said to have gained 80,000 cu. yds. of sand while Linwood Beach has lost only 25,000 cu. yds. The source of the extra 55,000 cu. yds. in the Lagoons Beach is not revealed. On page 18 of the syllabus, the Corps estimates that the maintenance of Linwood Beach will require 17,500 cu. yds. of sand every year. At that rate, our losses over the past five years since the breakwater have totaled 87,500 cu. yds. An 87,500 cu. yd. loss to Linwood is balanced somewhat with the amount of sand transferred to the Lagoons, and the amount of sand removed by dredging. The actual loss to Linwood is not 25,000 cu. yds., but 85,000 to 100,000 cu. yds.

2. An annual benefit of $55,600 is claimed for the additional beach created in the Lagoons. Under Corps Reg. EP 1165-2-1, no benefits whatsoever can be allocated for gains in a private beach that is not open to the public. The Lagoons Beach is not open to the public.

3. The total loss of Nakomis Beach was not considered. This beach was 100' wide and 500' long. It was a widely used public beach. Even with the addition of 2,350 cu. yds. of sand in December, 1975, Nakomis Beach has been lost to the breakwater.

4. Vermilion City Beach, a public beach, is now no bigger than it was in 1970 or 1971. The "gains" shown in Fig. 15 of the syllabus do not exist, and the annual monetary gain of $23,200 does not exist. Anyone can see this by visiting Vermilion City Beach.

The Corps has answered our protests about beach erosion with a counter-claim that the breakwater has really increased the size of our beaches. That may be a good political tactic but it is not good engineering or acceptable accounting. The Corps has underestimated the losses to Linwood Beach by a factor of 4 to 25,000 cu. yds. With losses cut in this fashion, it is possible to claim that the breakwater is actually creating beach with a benefit of $39,200 each year. Then the Corps, on page 18 of the syllabus, can say that removal of the breakwater is "inappropriate" because the breakwater has an overall beneficial effect on our beaches.

We have watched a beach 300' wide reduced to almost nothing. We watched the sand move westward into the Lagoons Beach, the river, and the harbor. We watched the dredges haul away our sand. A claim that the breakwater has created beach area in Vermilion is beyond belief, and it certainly does not reflect credit on the Corps.

Conclusion

It is most unfortunate that statutory safeguards for the public were disregarded in the pursuance of harbor modifications that were never needed and are not needed now. We cannot go back and make the Corps and the Vermilion Port Authority comply with these required precautionary procedures. However, the Corps should discard the various "benefit" estimates that have been presented over the past 33 years to justify the breakwater because they are not accurate.

The Corps is now assessing the real costs of repairing damages from the breakwater and preventing further damages, and the Corps must also assess benefits as realities. While we definitely need temporary measures to halt further beach erosion, permanent measures should not taken until a fair and equitable accounting of both costs and benefits is presented.

The benefits to navigation are minimal. If these benefits are stated accurately, it will be obvious that they cannot possibly balance the costs that have resulted from the breakwater.

The breakwater was a very poor investment of public funds. Alternative 1, removal of the breakwater, is the best possible, most beneficial, and least expensive solution for Vermilion Harbor.

Sincerely yours,

George W. Grossman

George W. Grossman

Linwood Park Cottage Owners Association, Inc.

August 31, 1978

STATEMENT TO THE PUBLIC MEETING
ON VERMILION HARBOR

Colonel Daniel D. Ludwig
U. S. Army Corps of Engineers
Buffalo District
1776 Niagara St.
Buffalo, New York 14207

Dear Colonel Ludwig:

We wish to express appreciation for the information packets on Vermilion Harbor which have been mailed to our members by the Buffalo District. These summaries and alternative proposals have been most helpful in preparing for this meeting.

We concur with the Corps' finding that the detached breakwater has caused erosion of Linwood Beach, and that mitigation of these damages should be undertaken. We also agree with Stanley Consultants' conclusions that the breakwater causes a diversion of polluted river water into our beach and creates an increased ice jam flood potential.

We note and endorse Stanley Consultants' conclusion that "Only removal of the breakwater will be completely effective in returning the shoreline to the pre-1972 long-term equilibrium state." However, we disagree with their subsequent statement that removal as a solution would not retain protection for navigation. Those of our members who have operated small craft in and out of Vermilion Harbor believe that the project purposes of aiding commercial fishing and recreational boating, and providing a harbor of refuge were met by Vermilion Harbor in its 1876-1972 status, with parallel piers only. We do not feel that the detached breakwater is essential to the project, and there is a question whether the projected benefits from the breakwater have been attained. Therefore, we continue to maintain that removal of the breakwater would be the best alternative for eliminating the erosion, pollution, and flood hazard problems. To avoid an impasse that could defer erosion control measures for a year while mitigation of pollution and flooding is examined, we propose the following definition of what a partially restored Linwood Beach should be for the short term:

1. The shoreline of Linwood Park should be useful in its entirety for swimming and the operation of small sailboats.

2. The beach should be of sufficient width and height so as to prevent wave attack on Linwood Bluff in major NE storms.

The Corps has contended, in the Section III syllabus, that Linwood Bluff came under wave attack in the pre-breakwater era. However, many of our members can attest that Linwood Bluff never came under wave attack in the forty or fifty years prior to 1973.

Our comments on the various alternatives for Section III mitigation are as follows:

Alternative 1 - Alteration of the Breakwater

Our position that removal is the best overall solution has been stated. The actual benefits to navigation derived from the breakwater appear to be outweighed by the costs to Linwood Park and flood plain residents.

Alternative 2 - Transport from Fillet at East Pier to Linwood Beach with Protection of Sewer Line

The pumping of sand from the east pier to Nakomis is an acceptable alternative that could be implemented within a short time to prevent further damage. This process could reduce harbor dredging and we request that this factor be considered as an additional benefit. Protection of the sewer line, which yields a higher cost/benefit ratio than beach restoration alone, is a definite advantage.

Alternative 3 - Transport of Harbor Dredged Material to Linwood Beach

We believe that harbor dredged material suitable for open-lake disposal should be placed in the near-shore water off Nakomis Beach. Any silt in such dredgings should separate out and dissipate by spring.

While the quantity of sand available from harbor dredging is not sufficient to restore Linwood and Nakomis beaches, it would help. Dumping this sand far out in the lake or placing it west of the piers causes a permanent loss to Linwood Beach. We recommend the combination of Alternative 3 with Alternative 2.

Alternative 4 - Nourishing Linwood Beach with Sand from External Source

Sand replenishment for Linwood Beach is obviously acceptable to us. Sand nourishment from an external source should be considered if the sand can be held in place with groins.

Alternatives 5 and 6 - Groin Fields at Linwood Beach

Groins are the most common structures used for shore protection. Linwood Beach is well adapted to groins because of the very low slope of the offshore shale. Our sand is easily pushed ashore. We feel groins extending 100' beyond the shoreline to a 5' water depth can be very effective.

Under our local conditions, it appears that groin spacing could be wider than shown in Corps plans. The east pier, only 400' long, held a beach 3500' to 3800' in length for over 100 years. Similar examples can be seen at many locations on our shore, such as Showse Park in Vermilion. A short groin here holds over 800' of beach even though the groin bypasses sand near the bluff. Further, local experience indicates that concrete groins are very durable, less costly, and much more attractive than rubble-mound groins.

The best examples of concrete groins can be found at Heidelberg Beach and the adjoining Ruetenik Gardens properties west of Vermilion. These groins have been adjusted in height to control sand bypassing. These groins, while possibly too closely spaced, have held protective beaches and have not limited recreational usage. The smooth top surface provides a recreational fishing site.

Our engineer members have been requested to evaluate the design and costs of successful concrete groins in our area and will forward their evaluation to Buffalo. There is no question that a groin field can be employed in the restoration of Linwood Beach. However, it is essential to reduce the cost of such an installation.

<u>Alternative 7 - Segmented Breakwaters at Linwood Beach</u>

While Alternative 7 is recognizable as a less expensive variant of the Lakeview Park project in Lorain, we must reject this alternative because it would limit the available recreational shoreline and present a safety hazard to both sailors and swimmers. The sailing of small boats from Linwood Beach has been a recreational activity here for many years. Curtailing the amount of shoreline as in Alternative 7 would bring sailing and swimming activities into conflict. This problem, coupled with a probable trapping of pollutants, makes this alternative unacceptable.

<u>The Proposed Revetment Alternative</u>

With the Corps finding that mitigation of beach erosion at Linwood Park is warranted under Section III, the 400' revetment proposed for the east beach at Linwood is unnecessary. A revetment is not needed to protect the sewer line if the beach is restored with sand.

Our position on the revetment has been stated in my letter of June 27, 1978 in which we contend that the revetment is not socially acceptable or environmentally sound. We have seen revetments in this area, and sand does not accumulate in front of them. Five years ago, in August, 1973, Corps representatives addressed our LPCOA meeting and told us we had no problems because our sand beach was the best possible protection for a bluff.

We conclude:

1. Removal of the breakwater would prove to be environmentally acceptable and economically justified, and that removal would not affect navigation.

2. To prevent further losses and damages to Linwood Beach and the sewer line, we endorse Alternatives 2 and 3, and we urge an early implementation of these alternatives as they are compatible with any possible overall solution.

3. The groin fields in Alternatives 5 and 6 appear to have merit when local conditions that would reduce costs are considered. We recommend further investigation of groin designs and spacing by the Corps and will forward our own evaluation.

4. Segmented breakwaters and a revetment are not acceptable to our members for the reasons stated.

We thank you for scheduling this public meeting and providing a forum where our views and other views may be heard and considered.

Sincerely,

LINWOOD PARK COTTAGE OWNERS ASSN., INC.

George E. Keidel

George E. Keidel, President

cc: Senator John Glenn
Senator Howard Metzenbaum
Congressman Donald Pease
Dr. Robert W. Teator, Director, ODNR
ODNR Staff
Mayor Jim L. Odom, Vermilion
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[illegible] BOULEVARD [illegible]
PITTSBURGH, PA 15222

August 29, 1978

U. S. Army
Corp of Engineers
Buffalo District
1776 Niagara St.
Buffalo, New York 14207

Attention: Colonel Daniel D. Ludwig

Subject: Vermilion Harbor, Ohio

Gentlemen,

The writer wishes to thank you for the information packet received from your offices relative to section 111 erosion study and the special impact study dealing with the Vermilion Harbor, and your syllabus' dealing with the same.

We first of all wish to refer to Page #S-4 and the specifically to Item #2 under the section entitled: "Stanley Consultants recommended that", wherein it is stated: "Assuming the beach is acceptable in its present state of equilibrium, etc". As a resident lease holder in Linwood Park, and as a stockholder in the Linwood Park Company, the writer wants it understood that he, in no way agrees with this particular assumption, and in fact, violently opposes any conclusions or actions, or non-action, based upon this false assumption.

The writer does, however agree with Item #5 under conclusions - Recommendations - Section 111 study, stating that, "Only the complete removal of the "monstrosity" will be completely effective in returning the shoreline to the pre-1972 long-term equilibrium state." This action would be desirable to establish the long-term equilibrium at the right point.

The writer calls attention to the fact that on the top of Page #S-5 the Stanley Study recommended that no mitigation should be considered for the increased flood potential. The writer urges the Corp never to forget the possibility of this flooding, as I firmly believe that it is a real danger to the residents of the lagoon area. The writer feels that the lagoon residents have been very lucky in that just the right [illegible] conditions have saved the lagoons from flooding. I do not understand why the lagoon residents are not very vociferous and even [illegible] on the frantic [illegible] with this "Flood threat". It has been [illegible] the [illegible] special way [illegible] different [illegible] would be [illegible].

I do [illegible] that [illegible] does not [illegible] correction. There is [illegible] small craft operation in the Vermilion Harbor [illegible] this [illegible] anyone [illegible]

[illegible]

[illegible] the waters of the river mouth, [illegible] that it [illegible] problems for all concerned except for the protection [illegible] properties immediately adjacent to the river mouth.

Relative to the various alternatives under section [illegible], the writer wishes to point out that only re-establishment of the Linwood east beach will provide proper and complete protection for the sewer line that is in jeopardy.

I believe that alteration of the breakwall in alternate [illegible] if it involved total removal of breakwall would be the best and most economical solution, when the cost of possible damages (flood and erosion and polution) are added up.

I believe that alternate #2 and #3 and #4 are acceptable as an interim means of getting the bluff protection needed until a more permanent establishment of beach protection for bluff and sewer is accomplished.

I believe that actually a combination of #2, #3 and #4 will be necessary as interim action.

Alternates #5 and #6 involving groins might be acceptable to help re-establish the beach protection for bluff and sewer provided that they were properly designed and spaced and installed. Rubbermold groins in the writer's opinion would not be acceptable as they undoubtedly would be a mess after a few years.

Alternate #7 - Segmented Breakwalls would not be acceptable in the writers opinion as it undoubtedly is an experimental thing and would "clutter" the water front and probably involve additional problems, over and above those already caused by the breakwall.

The writer wishes to re-iterate the fact that the proposed revetment idea presented for the sewer line above the Linwood east beach is totally not acceptable socially, or environmentally the the residents of Linwood Park in my opinion.

In summary, the writer wishes to thank the Corp for the invitation to the Public Meeting, Thursday evening, August 31, 1978 and this opportunity to express our views relative to the Corps' problems at Vermilion Harbor, Ohio.

Yours very truly,

[signature]

J. W. Rutledge

George W. Grossman
17125 Amber Drive
Cleveland, Ohio 44111

August 30, 1977

Colonel Daniel D. Ludwig
Buffalo District
U. S. Army Corps of Engineers
1776 Niagara St.
Buffalo, New York 14207

STATEMENT TO THE AUGUST 30, 1977
PUBLIC MEETING ON "IMPACTS OF
THE BREAKWATER", VERMILION, OHIO

Dear Colonel Ludwig:

This meeting has been called to discuss adverse environmental impacts resulting from construction of the Vermilion Harbor breakwater. We should also consider whether any real need ever existed to justify this structure, and whether the promised benefits have materialized. I contend that there was no need for the breakwater, that the benefits were illusory, and that the environmental problems should be resolved by removing the breakwater.

Vermilion Harbor, before the breakwater, was nearly perfect as a small-boat harbor. The harbor entrance had a desirable straight-in approach and an essentially unblemished safety record. A possibly unique balance existed between the river and the lake which kept the river channel free of sediment deposits. The only identifiable problem was periodic floods which usually resulted from ice jams.

Nevertheless, we are always willing to try to improve local conditions if someone else will pay for the improvements. Vermilion was no exception to this rule. In 1973, the harbor was "improved" with a breakwater constructed almost exclusively with federal and state funds. Almost immediately, environmental problems appeared. It is evident that solutions for these problems are needed very soon.

Before we start to consider various solutions, we should examine the political history of the breakwater. If there was no public need, if there are no public benefits, our problems should be resolved by restoring Vermilion Harbor to its 1972 condition.

Vermilion - A Successful Local Port - 1876 to 1972

In 1837, when the Corps constructed parallel piers to eliminate the sand bar blocking the river mouth, there was a national interest in the project. Lake Erie and the other Great Lakes were avenues of general commerce. Lake shipping served the same purpose as trucks today. By 1870, most of the commercial traffic in and out of Vermilion had moved to larger ports or shifted to the railroads. Vermilion might have become a small commercial port like Huron if the proposed railroad from southern Ohio had been completed. That project failed and by 1876, when the piers were repaired and extended to their present length, Vermilion was primarily a fishing port.

In 1903, Congress was requested to repair the piers and make harbor improvements. The repairs were funded but the improvements denied as not in the national interest. In 1911, Congress was asked to increase the width of the entrance channel. This proposal was rejected on grounds that the improvement would have only local benefits.

In 1916, the Corps recommended that Vermilion be abandoned as a federal harbor. This proposal was successfully fought by local interests and periodic Corps maintenance of the piers was continued. Twenty-one years later, in 1937, a Corps survey report recommending breakwaters and channel dredging was rejected because costs exceeded benefits. In 1942, a proposal for dredging alone failed for the same reason.

It was evident that, through all these years, both Congress and the Corps viewed Vermilion Harbor as a local port. During the first half of this century, local commercial fishermen met any challenges presented by the harbor without federal assistance. The entrance was narrow for sluggish 60' steam tugs drawing 6' to 10' of water. Fifty or more years ago, commercial fishermen changed to gasoline engine boats averaging 40' in length, 10' beam, and drafts of 3' to 5'. There were no accidents, no problems with the harbor entrance after the transition to smaller boats with more power.

If there was a need for harbor improvement, it was not recognized by the population of the village. The mayor, at a May 3, 1945 hearing, stated that the village was unable to contribute funds for harbor improvements, and that a considerable portion of the citizens probably would not favor such a contribution. Congress could not justify improvements, the Corps could not justify improvements, and local citizens were unwilling to pay for improvements.

The Vermilion Harbor Cost/Benefit Hoax

Fifty years of rejections of proposals to "improve" a local harbor at federal expense failed to dissuade certain Vermilion individuals from their efforts to federalize the harbor. Two points were clear. Dredging alone could never be funded as in the national interest, and a national interest had to be invented. The package of breakwaters and dredging was the only route to the federal treasury.

Therefore, in 1946, the Corps surveyed again and found that the breakwaters and dredging proposals of 1937 were now practical. By 1956, these proposals became a 100-page report which included theoretical analysis of several breakwater designs. The proposed open arrowhead design had an estimated first cost of \$853,000. Annual charges at 2½% interest were estimated at \$35,000. \$21,660 of this represented federal costs.

To justify the project to Congress, the Corps had to somehow show that total benefits exceeded total costs, and that federal benefits exceeded federal costs. This was accomplished, but any public accountant would face fraud charges for the cost/benefit analysis on Vermilion Harbor. The Corps estimated that the project would cause an additional 48.8 net tons of fish to be caught each year in Vermilion. How this was to be accomplished in a lake fished to capacity, with limits on some species, was not explained. The records indicate the number of fish caught in Vermilion is proportional to the amount of fish in the lake rather than the number of fishing trips. In 1946, 16 Vermilion boats made 2171 trips and caught 591 lbs./trip. In 1953, 16 boats made 1410 trips and caught 1805 lbs./trip. In 1952, the same boats caught only 1007 lbs./trip.

It was contended that 48.8 net tons of fish would sell for $20,300 and that the net profit would be 50% or $10,100. In addition, it was claimed that the ability to get out of the lake in storms would reduce losses of fishing nets. It was predicted that 9 trap nets and 45 gill nets would be saved at a value of $9,900. The total benefits, a neatly rounded $20,000, were held to be in the national interest. "Since these benefits are adding to the nation's resources by increasing the available food supply, they are considered general in character." No one considered the point that the available supply of fish is regulated by the fish themselves, and the conditions for their reproduction and growth.

The claim of a 30% increase in recreational boating resulting from harbor improvements was even more tenuous. The capacity of a harbor in dock space and launching ramps controls its growth. Many years before the project was installed, Vermilion Harbor reached capacity use through private investment in such developments as Romp's Water Port and Valley Harbor Marina. A claim that a breakwater and dredging could cause one more boat to be docked in Vermilion is incomprehensible.

Nevertheless, the Corps calculated an annual benefit of $77,000 to recreational boating, of which 50% was general and in the national interest. With $77,000 a year for boating, $20,000 for fish, and $10,000 for contingencies, $107,000 a year in benefits was claimed. The cost/benefit ratio came out to 3.1.

By May, 1972, benefits had been inflated to $475,000 per year with annual costs of $77,900 for a ratio of 6.1. In September, 1975, benefits were up to $634,200 per year. When comment to the September, 1975 draft EIS noted that these benefits from the project were equal to 42% of the total annual real estate tax revenue in Vermilion, the Corps replied:

> "The statement in question has been deleted from the Final Statement since it may be misleading in that it does not include the value of other benefits, such as sport fishing and windrowed ice protection, that may also be attributed to the project. Therefore, in order to avoid further confusion, the statement was deleted."

It is a good military tactic to withdraw when outnumbered but our environmental laws require cost/benefit statements. President Carter, a businessman with a sense for economic reality, addressed such tactics in his May 23, 1977 environmental message to Congress:

> "The accuracy, propriety, and integrity of water resource project cost estimation and benefit derivation are being challenged."

I challenge the accuracy, propriety, and integrity of the Vermilion Harbor benefit derivation. There are no tangible economic benefits. There never were any dollar benefits. Some homes are protected by the breakwater and some boats do not rub on their docks as much but such benefits are private, not even in the general local interest.

The Vermilion Environmental Debacle

The notice for this meeting has enume:ated all of these environmental impacts caused by the breakwater:

1. Erosion of Linwood and Nakomis beaches.
2. Periodic contamination of the Vermilion water supply.
3. Diversion of polluted river water to beach areas.
4. Changes in ice formation.
5. Increase in flood potential.
6. Increased sedimentation rates in the harbor.
7. Navigational hazards.
8. Aesthetics.

We are agreed that most or all of these environmental impacts exist and studies to quantify their effects are underway. Many of those present at this meeting will present statements to quantify such effects upon their personal lives. We should also examine whether such adverse results were predictable and why they were not considered prior to construction of the project.

The changes in the Lagoons-Linwood-Nakomis beach and the resulting erosion were totally predictable. Many people in Linwood Park recognized, intuitively, that the elimination of NW wave action by the breakwater would cause our beach to pile up at the east pier. We saw the changes begin in 1973 and we called in the Corps to tell them of our fears. It required additional study to learn that the sand-trapping abilities of offshore breakwaters were well understood by the Corps.

At the very time that the preliminary Section III report claimed that the Corps could not differentiate between beach erosion caused by the breakwater and beach erosion caused by high lake levels, the Corps knew that (1) high lake levels had not caused any beach erosion whatsoever at a similar beach east of the Huron piers, and (2) that offshore breakwaters were being designed for Lakeview Park in Lorain to trap and hold sand behind the breakwaters. Within an eleven mile radius from Vermilion, it was possible to distinguish between the effects from high water and the effects from a breakwater.

Even a cursory examination of the project plans, existing studies of littoral drift, and shoreline sand sources, by someone competent in coastal engineering, would have revealed that our beach changes and beach erosion could be predicted. We have acquired enough knowledge to predict that these changes are not complete. The east pier is no longer a barrier to westward sand flow. It will not become a barrier until the entire beach to the east recedes approximately 150' from its present position.

Increase in flood potential and increased sedimentation were also predictable. Where flooding is a problem, the customary solution is to impound water upstream, not downstream, from the area to be protected. Billions of dollars in dams illustrate this principle. While the Vermilion breakwater is technically a weir, "a partial dam of a river to raise its water level or divert its flow", it functions much like a dam.

Increased sedimentation was predicted by the Corps and provisions for dredging the federally-maintained river channel (which was not dredged from 1915 to 1974) were included in project costs. Unfortunately, the Corps failed to note that private channels, with a much larger area than the federal river channel, would also fill up with silt. That oversight could cost Vermilion's Lagoons residents $3000 each today and $3000 again in perhaps four or five years. Every real estate agent handling property in the Lagoons now advises prospective buyers of the possibility of dredging assessments to avoid liability for misrepresentation. This will reduce property values in the Lagoons.

Flooding, as a result of the breakwater, has not yet occurred. The breakwater can initiate a flood only by causing an ice jam. Whether the structure will reduce or increase the possibility of initiating an ice jam flood is arguable. Some think the breakwater will reduce flooding, many others have the opinion that more floods will occur. We do not know and the Corps does not know what will happen. Caution should have been indicated by such lack of firm knowledge. Enduring a flood is a painful way to obtain information.

However, we do know that the existence of a weir across the mouth of the Vermilion River will raise the level of a given flood flow over the level that would exist without the obstruction. The increase in level at a given flow is calculable and it could have been experimentally evaluated in the Corps' model study. This predictable effect was never considered. Furthermore, the course that a flood flow will take to evade the barrier across the river was never studied.

Pollution of the municipal water supply and local beaches was the most obvious, most predictable adverse impact. The location of the water intake is shown on most drawings of Vermilion Harbor. Almost anyone who saw a drawing of the detached "T" breakwater in place could envision the pollution of beaches that would result. However, a drawing of the project was not included in the draft environmental impact statement dated 30 September, 1971. The public was almost totally unaware that a diversion of flow would occur as a result of the project.

Only those government agencies with access to the general design memorandum were aware that plans had been changed from a non-diverting open arrowhead breakwater design to a diverting detached "T" design. When one of these agencies, the Ohio Dept. of Natural Resources, commented that the design would bring "roiled river water and unsightly debris in contact with the public and private bathing beaches in the immediate area", the Corps agreed that this was "an admitted possibility during periods of high river discharges; however, the duration of such conditions is limited."

It is impossible to contend that pollution that is intermittent and limited in duration is acceptable pollution. The filthy water brought to our beaches by the high river discharge of July 4, 1977 remained for almost two weeks, ruining the vacations of visitors to Linwood Park during that period. The annual late winter upsets of the water last only a few days but they disturb everyone in Vermilion. The river water conditions that led to the death of our duck colony in the harbor lasted only a few weeks but the deliveryman who brings bottled water to our residence added seven new Vermilion customers after this incident.

The water pollution caused by the breakwater was predictable. The only reason for changing from the original arrowhead design to the polluting detached "T" design was to reduce the cost of "improvements." The arrowhead design was tested and found to be effective. The best arrowhead design required 30 circular cells, 35' in diameter. The final detached "T" design needed only 22 circular cells. Our water was polluted for the price of 8 - 35' diameter circular cells constructed of steel piling. We were not aware of that until the breakwater was installed.

We simply never had an environmental chance in Vermilion. The final environmental impact statement, dated 3 May, 1972, contains a five page list of those who received the 30 September, 1971 draft statement. Copies were sent to some 110 individuals and organizations in Toledo, New Concord, Ashtabula, Newbury, Hudson, Litchfield, Leetonia, Newton Falls, Struthers, and Canton, Ohio. No names in Vermilion or even Erie County are shown on this list.

City officials or the Port Authority apparently received a copy of the DEIS for they commented on October 18, 1971 that "The citizens of Vermilion all enthusiastically approve and endorse the environmental statement and urge an early completion of the project." That was an unfortunate statement. The public, in Vermilion, never had an opportunity to approve the environmental impacts of the project.

Who's to Blame?

We are.

The citizens of the United States are to blame for tolerating a political system where such wasteful and environmentally disastrous projects as the Vermilion Harbor breakwater can pass as "progress." The mere fact that the federal government appropriates funds for a project in a particular area tends to establish the legitimacy of that project in the public mind. When local taxes are assessed for paving, sewers, or water lines, our standards for investment are stringent. When it's federal funds that are being spent, we have no standards.

It is convenient to place all the blame on the Corps, but the Corps is simply a middleman, a supplier. The cost/benefit analysis on Vermilion Harbor deserves an "F" in accounting but it was not immoral by our standards of a few years ago. Those who approved the project believed that all those benefits would really happen. They wanted to believe there would be no environmental costs.

Environmentally, the breakwater is a relic, an anachronism, an antique. It represents a time when we gave no thought to the environmental costs of our actions. We passed our sewage on to someone else without a second thought. We built without any consideration of the consequences to others.

That era ended, or should have ended, in 1969 with the passage of the National Environmental Policy Act. The Corps failed to catch on fast enough to prevent the Vermilion disaster. The same finesse that had been traditionally applied to cost/benefit ratios was applied to the environmental statement process. If one can catch fish and save nets with a breakwater, it is easily possible to dismiss pollution as "limited in duration" and ignore beach erosion. Now, we are faced with the reality that there are no benefits - only costs - and we, in Vermilion, have to pay those costs.

The Solution for Vermilion Harbor

Two types of solutions are available to us in Vermilion. The breakwater portion of the project can be discontinued, or the breakwater can be structurally altered to eliminate some of its undesirable effects. Fortunately, we know what we'll pay if the breakwater is removed. The beaches will revert to their pre-1972 conditions of stability and purity. Waves will again enter Vermilion Harbor to scour out the silt. The harbor entrance would be what the Corps has termed "a desirable straight-in approach." The water intake location would be viable and flood potential would be diminished. However, some dock locations would experience light wave action.

Structural modifications and additions are possible. At a minimum, the river must be restored to its former course. Groins and sand fill, or sand replenishment, for Linwood and Nakomis beaches are a necessity if these beaches are to coexist with the breakwater. Harbor silting and flood potential problems might be alleviated to some extent by modifications. However, if waves are to be kept out of the harbor, the price must be paid in dredging.

No consideration should be given to modification of the project until a favorable cost/benefit ratio has been established for the breakwater as is. The public cannot be expected to accept benefit derivations that started out in 1956 at $107,000, escalated to $634,000 a year in 1975, and then were withdrawn in 1976. The Corps is legally required to prove that national benefits exceed federal costs and that total benefits exceed total costs, even at 2½% interest.

We had years of engineering studies on Vermilion Harbor. We now have lawyers studying the legality of diverting a polluted river into bathing areas and our water supply. It is time to bring in independent public accountants for an unbiased cost/benefit study.

If the breakwater cannot be justified as it stands, it should be removed. If benefits can be shown to exceed costs now, it is then necessary to add in the costs of correcting the environmental problems and calculate a new ratio. The initial cost/benefit analysis can be and should be available concurrently with the conclusion of the special impact study and the Section III study in early 1978.

It is difficult, perhaps impossible, to put a price on intangible environmental problems such as flood risk and the aesthetics of building groins on an attractive 3700' stretch of beach. Therefore, the public must be consulted at every step to a solution. We cannot afford to repeat the mistake of allowing the Corps to determine that a river diversion would be environmentally acceptable. We are the customer - we are paying. Our rights as the customer should not be assumed by the Corps.

Time is an extremely important factor and 1980 is three years off. We should not be expected to endure three more summers of polluted water. Lagoons residents should not have to participate in a three-year study of flood potential. Our beach can disappear and fill the harbor entrance with sand in just twelve hours of a massive northeast storm. The Corps may have time to study and plan but we don't know how much time we have.

We need a decision from the Corps and from the City of Vermilion. If there is not enough information, enough knowledge, to accurately assess what the breakwater is doing and will do, the structure should be dismantled.

The breakwater should go the way of the original cost/benefit ratio - it should be withdrawn.

Respectfully submitted,

George W. Grossman

George W. Grossman

cc: All Concerned

153 Pickwick Drive
Northfield, Ohio
August 29, 1977

Col. Daniel Ludwig
District Engineer
Buffalo District, Corps of Engineers
1776 Niagara Street
Buffalo, New York 14207

Dear Col. Ludwig:

This letter is comment submitted for the August 30, 1977 Public Meeting on Impacts of the Breakwater at Vermilion Harbor.

I am a resident of Northfield, Ohio and also own a summer cottage on Ash Street in Linwood Park at Vermilion. I am a member of the Linwood Park Cottage Owners Association and a part-owner of the Linwood Park Company.

I welcome the opportunity to comment on the Impacts of the breakwater and will address the following points:

1. What's good about the breakwater.
2. What was supposed to be good about the breakwater but actually isn't.
3. The adverse impacts caused by the breakwater.
4. The fallacy of blaming erosion on high water levels.
5. Recommendations for action.

First - what's good about the breakwater?

It does reduce wave action in the river channel and boats that are in the outer part of the harbor don't rock as much. That is the breakwater's only apparent real benefit.

Second - Improvements that were supposed to occur but didn't.

There was supposed to be some advantage to commercial fishing. There is not. Kishman's fishing boats go about their business the same as before and any changes to the fishing pattern are due to the number and types of fish in the lake - not to any changes in the harbor design.

Recreational boating was supposed to be improved. There is no evidence of improvement. There has been no massive increase in the number of recreational boats using the harbor or any substantial increase in marina facilities. Obviously the public does not perceive Vermilion Harbor as having improved. In fact, for people

operating sailing craft, it's very often more difficult to get in and out of the harbor due to the obstruction of the breakwater.

The harbor was supposed to become a refuge for small craft in severe weather. We have no evidence of any instances where the breakwater provided refuge for boats in distress. On the contrary, we had an instance last year when calm water behind the breakwater lulled a race committee into a false sense of security and the consequence was a sailboat rolled over by six-foot waves as soon as it left the harbor. The rescue of the crew was dramatic, but that boat would probably never have left the harbor if the breakwater had not been there.

Going on to adverse impacts.

The swimming areas on both sides of the river are grossly polluted by the diversion of the Vermilion river across the beaches. This pollution includes sewage plant effluent, runoff from developed areas, and construction work, and raw sewage from boats in the harbor. The corner at the intersection of the Lagoons beach and the East pier is almost always a black, noxious mess. Most days during the summer the beaches are polluted visibly by detergent bubbles and floating debris. From a heavy rain that occurred this past July 4th, the water in the swimming areas was dirty brown for two full weeks. Previous to construction of the breakwater, all this pollution flowed straight out into the lake and was dispersed over a large area.

The breakwater is the direct cause of a massive change to the contours of the Lagoons-Linwood-Nakomis beach. Prior to construction of the breakwater, this beach had been stable and had suffered no erosion. This is amply documented by survey drawings and aerial photographs going back nearly a hundred years. Through high water and low water and with storms coming from all directions, this beach changed very little. The breakwater presents a wind shadow that prevents Northwest waves from reaching the beach and equalizing the forces of Northeast waves. Three strong Northeast storms last spring and summer rolled all the sand out of the eastern one-third of this beach allowing wave action to erode the overhanging bluff and topple several large trees.

The beach sand has piled up at the East pier and much of it has flowed around the pier. How much sand has been lost from this beach? We know that about 20,000 cubic yards was dredged and thrown away into the lake in 1975. From a study of aerial photographs, I estimate that an additional 40,000 cubic yards has flowed around the piers in the last three years. It costs approximately $6.00 per yard to truck

sand into this area. I conclude that the replacement cost of the sand already lost from this beach is $360,000 with more sand being lost every time there is wave action from the Northeast. I invite you to make your own calculation if you don't agree with these numbers. Those people on the West side of the piers who are now acquiring new beaches should understand that the average direction of longshore sand drift in this part of Lake Erie is to the ~~East~~ West and all that sand that passes around the piers will keep moving until it reaches the beaches and harbor structures East of Huron.

The breakwater also acts as a dam slowing the flow of water into the lake. Upstream runoff in the form of suspended solids is settling out in the harbor instead of washing into the lake. The entire harbor needs to be dredged now and the economic impact ($450,000) to residents of the Lagoons will be severe.

I would like to comment at this time on the "high-water" theory. We hear over and over that beach erosion in the Great Lakes is due to "high-water". I submit that there is no scientific or engineering validity to that statement. Beaches are only eroded by wave action and wave action is a function of wind velocity and direction, fetch distances, and the interference of natural and man-made shore structures and offshore structures. I repeat what I stated before - previous to construction of the breakwater and its interference with established wave patterns, there was no erosion and no significant change in contour of the Lagoons-Linwood-Nakomis beach no matter how high or low the water level.

Don't be lulled into an incorrect conclusion by looking at the eastern portion of this beach and correlating this with lower lake levels this year. The narrow beach at the East end is sand that was rolled back by strong Northwest winds last fall. They were equal in strength to the Northeast winds of last spring and summer, but did not restore the beach to its original contour. There have been no strong Northeasters this year, but our experience of last year tells us that the next wind that generates 8 to 10 foot waves for 24 hours will again roll all the sand away from Nakomis and the eastern part of Linwood. This will happen even if the average water level is two feet or even four feet lower than it is now.

You should realize that the adverse impacts from the breakwater are much more severe than the minimal favorable effects. The proper and least cost solution to our problems is complete removal of the breakwater and replenishment of lost beach sand. A decision to keep this structure while still trying to mitigate the adverse impacts will lead to modifications that will cost as much as the breakwater's original cost, groin fields on the beaches, and continuing sand haul or sand replenishment programs.

In conclusion, we don't need this breakwater, - it does more damage than it does good, - its adverse impacts are too expensive, - and it ought to be removed!

Respectfully yours,

David T. Berns

David T. Berns

DEPARTMENT OF THE ARMY
BUFFALO DISTRICT, CORPS OF ENGINEERS
1776 NIAGARA STREET
BUFFALO, NEW YORK 14207

NCBED-PW

4 August 1978

Dear Participant:

The Buffalo District has recently completed the initial phase of our investigation to determine the effect the detached breakwater at Vermilion Harbor has on the surrounding area. The two reports documenting the studies are:

a. Vermilion Harbor, Ohio, Breakwater Impact Study, Study of the Impact of the Offshore Breakwater on: Municipal Water Supply; Swimming Area and Beaches; Ice Jam Flooding; Free-Flow Flooding; Sedimentation; Navigation; and Aesthetics, dated April 1978.

b. Vermilion Harbor, Ohio, Section 111 Study - Study of the Impact of the Federal Navigation Structures on Shoreline Processes (Draft Report), dated May 1978.

This letter is to provide you summary information on the results from these two reports prior to the 31 August 1978 Public Meeting. The purpose of the Public Meeting is to present the results of the current phase of the two companion studies and solicit your views on the future course of action you would prefer for Vermilion harbor. I trust that this summary is sufficient to allow you to actively participate in the public meeting. However, loan copies of the two reports can be obtained at the following locations if you are interested in reviewing the reports:

Ritter Public Library
5680 Liberty Avenue
Vermilion, OH 44089

Vermilion Port Authority
Town Hall
Vermilion, OH 44089

41a

NCBED-PW

Honorable Jim Odom
Mayor, City of Vermilion
Vermilion Service Center
5335 Devon Dr.
Vermilion, OH 44089

Linwood Park Company
Superintendent's Office
Linwood Park
Vermilion, OH 44089

Until the supply is exhausted, individuals can purchase personal copies of either (or both) reports at the printing cost of $16.06 for the Section 111 Study and $31.10 for the Special Impact Study by writing to the Buffalo District at the address shown on the public notice. Please remit a check, payable to the U.S. Army Engineer District, Buffalo, with the request.

Inclosure 1 is the information packet that summarizes the results of the Section 111 Erosion Study and the Special Impact Study and my decision on further action at Vermilion Harbor. Inclosure 2 outlines the format and agenda for the meeting. If you have any questions on this matter, call my Project Manager, Mike Wojnas, at (716) 876-5454, ext. 2263.

I encourage you to attend and participate in the public meeting on 31 August 1978.

Sincerely yours,

Daniel D. Ludwig

2 Incl
as stated

DANIEL D. LUDWIG, PE
Colonel, Corps of Engineers
District Engineer

INFORMATION PACKET
ON
THE RESULTS OF THE
VERMILION HARBOR, OHIO
SECTION 111 EROSION STUDY
AND
SPECIAL IMPACT STUDY

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AND
SPECIAL IMPACT STUDY

1. The Vermilion Harbor Project. The Vermilion Harbor navigation project (see Plate 1) consists of parallel piers, a detached breakwater, lake approach channels, an entrance channel, and river channels, all maintained by the Federal Government. The existing project was constructed in stages as authorized by the River and Harbor Acts of 1836, 1875, 1905, and 1958. The most recent phase - construction of the detached breakwater - was completed in 1973. Project purposes include commercial fishing, recreational boating for shallow-draft pleasure craft, and a harbor of refuge for small craft.

2. Events Leading to the Shore Erosion and Special Impact Studies. Since May 1974, Buffalo District has received complaints from the Linwood Park Cottage Owners Association (LPCOA) that the detached breakwater, constructed in 1973, is causing erosion of its nearby shoreline. Subsequent letters on this and other matters from concerned citizens supporting LPCOA's position and urging remedial action by the Corps of Engineers resulted in a decision by the Buffalo District Engineer to conduct a cursory review to establish the validity of the complaints. It was concluded that many of the problems identified by the citizenry were either not addressed in the original planning documents or not investigated in sufficient depth to satisfy the local concerns. Further, review by Buffalo District indicated that the LPCOA had correctly identified several adverse impacts, although the magnitude of the adverse impacts could not be quantified. Therefore, in December 1975 funds were requested to prepare a study of possible adverse effects (other than shore erosion) caused by the breakwater construction. Funds from the Corps "Operations and Maintenance" program were requested to perform the Special Impact Study. Because there is a specific authorization for investigating mitigation of shore erosion problems, the erosion study for Vermilion Harbor could not be included as an item under the Special Impact Study. The basic authority for investigating the problem of possible shore erosion is Section 111 of the River and Harbor Act of 1968 (PL 90-483).

In response to a 31 July 1974 request from the State of Ohio, the Buffalo District Engineer initiated the Section 111 Study to address possible effects of the harbor structures on the adjacent shoreline.

3. Impacts Investigated.

a. Section 111 Erosion Study - As stated above, and as the name implies, only the shoreline change (beach erosion) problem was addressed under the Section 111 authority.

b. Special Impact Study - A number of adverse impacts were identified by concerned citizens (particularly spokespersons for the Linwood Park Cottage Owners Association) in the Vermilion area. As a result of public input, the impacts of the detached breakwater on the following seven items were investigated:

(1) Periodic contamination of the Vermilion municipal water supply.

(2) Diversion of Vermilion River water into, and pollution of, adjacent recreational swimming area.

(3) Increase (or decrease) of ice formation in the calm waters shoreward of the breakwater at the harbor entrance and increase (or decrease) in probability of ice jam flooding.

(4) Increase in flood potential on Vermilion River due to raising the river water surface profile.

(5) Rapid sediment accumulation in the Vermilion River and increase in sedimentation in the adjacent private lagoons causing increased dredging costs.

(6) Navigation hazards due to traffic congestion at the mouth of the entrance and blind corners.

(7) Aesthetics.

4. Objective of Current Phase of Study. The study objective for this phase of the study was, where practicable, to provide quantitative evaluations of the impacts. Otherwise, the conclusions were to be qualitative in nature. Thus, the Corps goal, in this phase, was to determine whether or not the impacts are sufficiently adverse to warrant mitigation. If it was concluded that mitigation was required, the type of mitigative measures to be constructed were to be evaluated in a subsequent stage of the study.

5. Public Involvement and Study Progress.

a. Public Involvement - An Orientation Public Meeting was held at Vermilion High School on August 30, 1977. Approximately 130 interested citizens, officials of various Federal, State, and local

agencies, and representatives of special interest groups attended the meeting. Since the public meeting, Corps staff involved in the study have had numerous discussions with officials at various levels of Government and interested citizens to obtain information on the study area and to discuss preliminary study results. All known interested parties were sent copies of the information packets for the August 1977 public meeting and this public meeting.

b. Study Progress - As was stated at the August 1977 public meeting, Stanley Consultants of Cleveland, OH, and Muscatine, Iowa, was hired by the Buffalo District to conduct the Special Impact and Section 111 Erosion Studies. The Scope of Work for these two studies specified that Stanley Consultants conduct investigations to quantify the significance of the favorable and adverse impacts created by the detached breakwater with the objective of recommending whether or not mitigation of adverse impacts should be considered. Stanley's recommendation for mitigation was to be predicated upon their evaluation of the significance of the adverse impact. A summary of Stanley's findings on each of these eight impacts is included as Attachment 1 of this packet. The Stanley draft report on the Special Impact Study was submitted to Buffalo District for review and comments on 16 February 1978. Stanley Consultants incorporated these comments, as appropriate, into their final report submitted to Buffalo District on 28 February 1978. The draft of the Section 111 Study was forwarded to Buffalo District on 23 March 1978, and the final version was furnished on 1 June 1978. Attachment 2 provides Stanley's summary conclusions on this study.

The final versions of the Stanley reports were reviewed by Buffalo District and a position paper on each was prepared. These Buffalo District position papers are included as a syllabus to the respective Stanley Reports. The Buffalo District Engineer's conclusions and recommended future course of action as presented in the Syllabi are included herein as Attachments 4 and 5.

Copies of the two reports, with Syllabi, have been sent to the addresses listed in the cover letter for loan to interested individuals who wish to review the reports.

6. Results of Stanley Consultants' Studies.

a. Special Impact Study - The investigation of, and the conclusions reached are presented in the report titled Vermilion Harbor, Ohio, Breakwater Impact Study - Study of the Impact of the Offshore Breakwater on: Municipal Water Supply; Swimming Area and Beaches;

Ice Jam Flooding; Free-Flow Flooding; Sedimentation; Navigation; and Aesthetics, dated April 1978.

The summary and conclusions reached by Stanley Consultants are presented in Chapter 10 of the April 1978 report. The six pages of Chapter 10 are included herein as Attachment 1.

To summarize, Stanley Consultants concluded that mitigation should not be considered for:

(1) Contamination of the Vermilion water supply;

(2) Increased flood potential for the free-flow condition;

(3) Navigation hazards; and

(4) Aesthetics;

and that the breakwater is creating an adverse effect on and mitigation should be considered for:

(1) Ice jam flooding by increasing the ice jam potential at the harbor entrance; and

(2) The recreational swimming areas to the east by diverting polluted Vermilion River water to them.

Stanley also concluded that the breakwater has not had a significant impact on the Vermilion River channel upstream of Erie lagoon or any of the four lagoons, and that conclusions regarding deposition at the river entrance and the lake approach channels cannot be reached until the subsequent comprehensive study of shoreline erosion and sediment transport under Section 111 is completed. In the Section 111 Report (page 43), Stanley states..."The channel deposits in the lake approach channel and river channel are caused by the offshore breakwater."

b. Section 111 Erosion Study - The conclusions of Stanley's Section III study are presented on pages 41-47 of the report titled: Vermilion Harbor, Ohio, Section 111 Study - Study of the Impact of the Federal Navigation Structures on Shoreline Processes, dated May 1978. Attachment 2 to this information packet is a copy of those pages.

One of the major conclusions of Stanley's study specified that the offshore break water has contributed significantly to shoreline reorientation as characterized by accretion near the piers and erosion at Linwood Beach. Attachment 3, reproduced from Stanley's

Section 111 Report, graphically shows the estimated change in long-term equilibrium at Vermilion produced by the detached breakwater.

7. Buffalo District Findings. Stanley Consultants' Special Impact Study and Section 111 Study were reviewed and evaluated by the Buffalo District Engineer and his staff. The results of this analysis and the decisions reached by the District Engineer are presented as a Syllabus to each of Stanley's studies, and included herein as Attachments 4 and 5 for your information.

The methodologies used by Stanley Consultants are consistent with good engineering practice and the contract requirements. Except for the Buffalo District's position that the lakeward limit for the post-breakwater equilibrium state will extend further lakeward than shown on Attachment 3, the conclusions reached by Stanley Consultants are considered reasonable.

8. Other Related Investigations Underway at Vermilion. In addition to these two studies, Buffalo District has recently completed (May 1978) a study to determine the viability of protecting an endangered interceptor sewer line located on the bluff at Linwood Park. This investigation was made under the authority of Section 14 of the 1946 Flood Control Act, as amended. Section 14 provides the Corps of Engineers authority for constructing emergency streambank and shoreline protection of public works and non-profit public services.

Three plans of improvement were considered for protecting the interceptor sewer at Linwood Park, and a rubblemound revetment about 400 feet long was selected as the proposed plan of improvement under Section 14. The rubblemound revetment alternative was selected because it would provide the most complete, least expensive protection for the bluff and the sanitary sewer interceptor.

Several of the alternative designs presented in the Syllabus to the Section 111 Study (see Attachment 5) would protect the interceptor at Linwood, thus eliminating the need for the Section 14 revetment. These Section 111 alternatives are: beach nourishment at Linwood Beach (Alternatives 2 and 4 of Attachment 5), the groin field with nourishment (Alternative 6); and the segmented breakwaters with nourishment at Linwood Beach (Alternative 7). Similarly, possible measures to mitigate ice jam flooding and pollution of Lagoons and Linwood Beaches under the Special Impact Study could preclude the need to construct such permanent works as the groin field or the segmented breakwater under Section 111. Thus, the decisions made regarding each of these three studies must consider the effect on the others to insure compatibility and prevent redundancy.

9. Schedule of Future Activities. After considering the information provided at the 31 August 1978 public meeting, the Buffalo District Engineer will decide upon the future course of action on constructing the revetment under Section 14 and the alternative for mitigation of shoreline damage to be carried through final design under the authority of Section 111. The decisions on these two matters will be announced through the media and interested organizations and local government officials will be notified. Final design for the Section 111 must then be prepared and approval of the Buffalo District Engineer's recommendation obtained from Corps higher authority. The schedule for completing this action is indeterminate until the Section 111 mitigative measure is selected.

It is expected that the additional studies of the beach pollution and ice jam flooding problems for the Special Impact Study will be performed by a consulting firm. The contract would be awarded in the fall of 1978, and contingent upon the amount of field data required, the Special Impact Study could be completed in late 1979.

The study results, recommendations made, and decisions reached would be made public and a public meeting held, if deemed appropriate.

5 Attachments
1. Chapter 10 (Conclusions) of Stanley Consultants' Special Impact Study Report
2. Section 5 (Conclusions) of Stanley Consultants' Section 111 Report
3. Map Showing "Change in Shoreline Equilibrium Since Breakwater Construction"
4. Syllabus to the Special Impact Study Report
5. Syllabus to the Section 111 Report

NOTES AND AGENDA
Information Public Meeting on
The Special Impact Study and Section 111
Shoreline Damage Study of the
Federal Navigation Project
at
Vermilion, Ohio

1. NOTES

Registration Cards. You will be given a registration card at the meeting. Please give your completed registration to any meeting official. These cards become a part of the meeting record. Make sure you indicate whether you wish to make a statement.

Statements. Written statements are preferred for the sake of accuracy, but oral statements may be made without a written document. Written statements need not be read; they become part of the official record whether or not read aloud. Prepared statements may be submitted to any meeting official.

Meeting Proceedings. You may record the proceedings of the meeting if you wish; however, a professional stenographer will record the proceedings, and transcripts of this record will be available at cost from the District Engineer, U.S. Army Engineer District, Buffalo, 1776 Niagara Street, Buffalo, NY 14207.

2. AGENDA

Opening Remarks, Introductions, and Corps Presentation. Colonel Daniel D. Ludwig, District Engineer, U.S. Army Engineer District, Buffalo.

Presentation of Views. (Each group will have an opportunity to speak but not necessarily in the order listed).

(1) Members of Congress (or their representatives)

(2) Representatives of the Governor

(3) Members of State Legislature

(4) Representatives of Federal Agencies

(5) Representatives of State Agencies

(6) County Officials

(7) City Officials

(8) Interested Individuals

(9) Representatives of Civic Organizations

<u>Closing Comments</u>. Colonel Daniel D. Ludwig

CORPS OF ENGINEERS U.S. ARMY

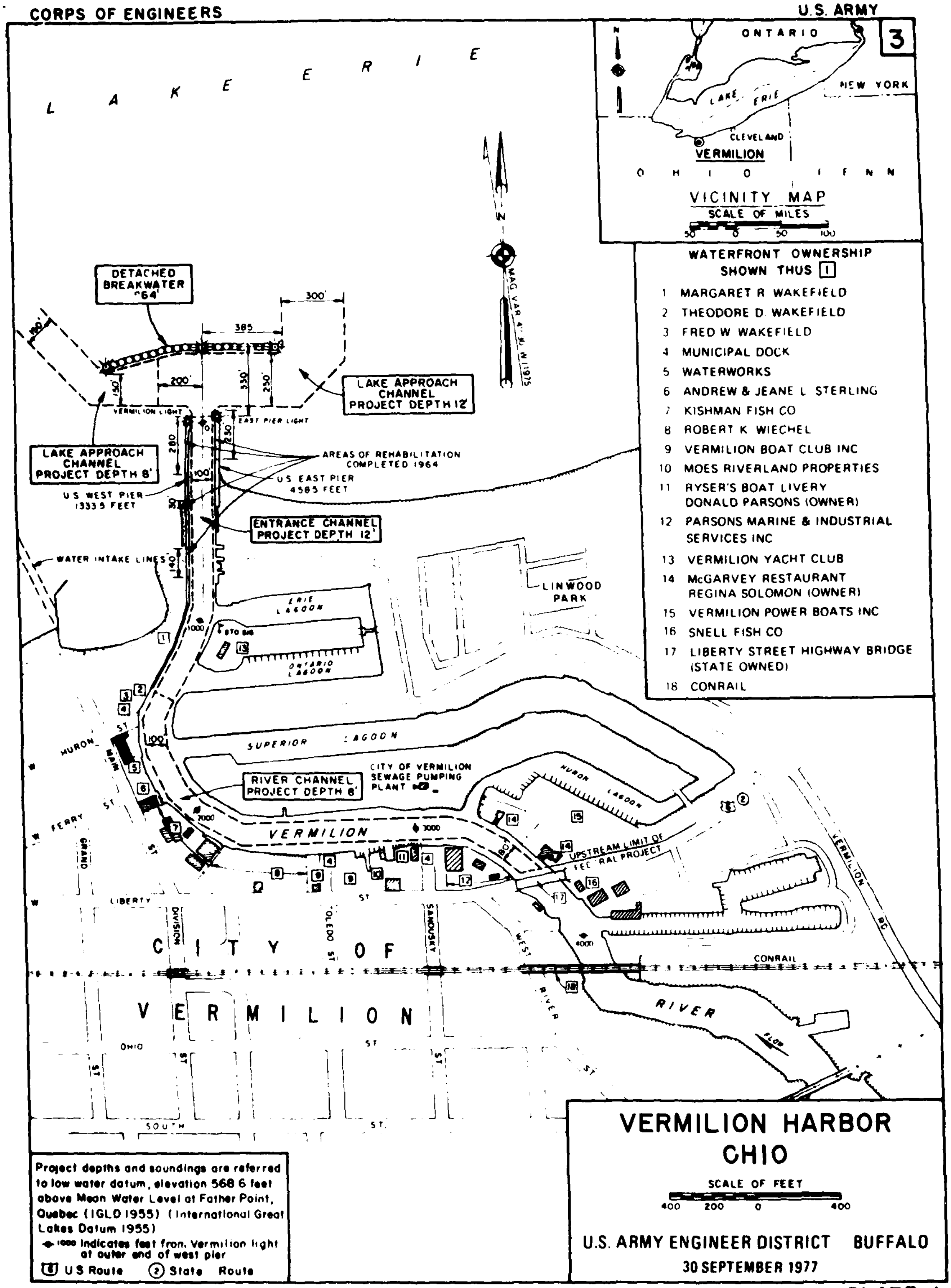


PLATE I

SECTION III

SHORELINE EROSION STUDY

CHAPTER 5

SUMMARY AND CONCLUSIONS

May 1978

Attachment 2 (7 Pages)

SECTION V - IMPACT OF FEDERAL NAVIGATION STRUCTURES

Impact on Shoreline Alignment and Beach

Distribution - The federally constructed improvements at Vermilion Harbor have significantly affected shoreline conditions in the Vermilion Harbor area, beginning with the construction of the parallel piers in 1836. Significant erosion of the western shore occurred within 10 years, and an accretion of 500 feet occurred to the east of the piers during the same period. The shoreline then stabilized at an equilibrium alignment which was maintained with little significant change until 1972. Although this initial erosion from 1837 to 1847 was substantial, no serious consideration of mitigation of these effects is warranted at this point over 130 years later.

The most recent alteration in shoreline alignment began in 1972 and continued to 1976, spanning the 1973 construction of the offshore breakwater. Although the breakwater could not have been the cause of the initial change, it appears that the presence of the structure accelerated the accretion of sand in the 800 to 1,000 foot area adjacent to the east pier by blocking the erosive power of northwesterly waves. A rigorous mathematical analysis of littoral transport does not predict a significant accretion of sand in this area. However, a shift in the equilibrium angle of the beach east of the piers of up to 10 degrees is predicted, which agrees well with the observed change.

The critical question is whether or not the shoreline will continue to accrete in the vicinity of the east pier and erode at the east end of Linwood Beach. Recent surveys and photos indicate that no further re-orientation of the shoreline has occurred since 1976. In fact, some accretion has occurred at the east end of Linwood Park (see Figures 14 and 16), probably resulting from incoming sand from the east. No recent significant reduction of the accreted deposit at the east pier is evident, however.

The mathematical analysis of littoral processes predicts that eastward transport should occur, and some reversal of the 1972-76 pattern would be expected. The future shoreline alignment may also be affected by unusual wind distributions.

After consideration of all the factors involved, it is our opinion that no further clockwise shift in shoreline orientation is likely.

Impact on Sediment Budget

As discussed previously, the influx and outflow of sediment to the Lagoons-Linwood Beach system is very difficult to evaluate. Inflow from the bluff to the east can vary from 1,000 cubic yards of beach building material per year to over 15,000 cubic yards per year depending on erosion factors such as storm incidents and lake levels. These rates have not been affected by the federal navigation structures.

The movement of material onshore or offshore also can not be ascertained with any degree of accuracy. The lack of sand presently existing offshore at depths greater than 5 to 6 feet indicates that the importance of onshore-offshore movement is negligible except in the vicinity of the river, where river discharges may have diverted littoral material offshore. However, sand thicknesses up to an inch or two would be undetected by surveys, and yet could represent a significant volume over the 3,000 foot length of Linwood Beach.

Flow of sand around the ends of the harbor channel piers is also impossible to predict. From sediment budget considerations, values on the order of 1,000 to 4,000 cubic yards per year seem reasonable. There is no evidence that westerly sand transport around the piers has increased since construction of the breakwater. However, deposits of sand have occurred in the river and lake approach channels, requiring dredging on three occasions (see Figure 16). These deposits are created by sand transport from short-term wave events. Specific storms move sand into these areas, and the breakwater prevents waves from

returning the material to the littoral system. High river flows may have also scoured sand from deposits at these locations and transported it out the east lake approach channel, resulting in loss of material to deeper water. The channel deposits in the lake approach channel and river channel are caused by the offshore breakwater.

Environmental Effects of Shoreline Erosion

The following discussion focuses on the potential environmental impacts of shoreline erosion. Impacts on the aquatic biology, water quality, terrestrial ecology, and socioeconomics are of primary concern.

Sediment resulting from shoreline erosion has a detrimental effect on aquatic biology. Siltation and turbidity lessen light penetration of the water and blanket plants, phytoplankton, and benthos with a layer of silt. These circumstances result in a lack of vegetation and pollution tolerant benthos. The lack of vegetation results in increased turbidity and a reduction in fish species which use areas of aquatic vegetation for feeding, spawning, and protection. Studies performed by Ryclaman, Edgerly, Tomlinson and Associates and the Cleveland Environmental Research Group in 1975; and by the Ohio EPA in 1972, document these conditions in the Vermilion area.[16]

As the bluff is eroded, trees are undermined and fall into the lake. Loss of this habitat is expected to have little overall effect on terrestrial wildlife since existing habitat quality is generally poor. The aesthetic impact from the loss of trees probably is more significant than the loss of habitat.

Aesthetic impacts include not only the adverse visual impact of the absence of the trees, but also the undesirable brownish color of the water due to turbidity when severe erosion occurs. Such adverse visual impacts can degrade the recreational experience for swimmers, boaters, and sightseers.

Another consideration of shoreline erosion is social well-being. Property owners living near the bluff undoubtedly have a concern for the future of their land and structures. The psychological impact of these concerns cannot be measured. In addition to these psychological concerns is the question of property values for those parcels adjacent to the eroding bluff. Physical loss of property from erosion and the impending threat to structures could depress property values.

<u>General Alternatives for Mitigation</u>

In the event that a decision is made to restore the Lagoons-Linwood Beach system to its pre-1972 condition, several alternatives should be investigated. They basically fall into three categories.

1. Alteration of the breakwater.
2. Artificial transport of sand.
3. Construction of shoreline protection structures along the Lagoons-Linwood shoreline.

Artificial transport of sand could be employed to move sand accreting at the east pier back to the Nakomis area. The resulting shift in shoreline alignment would restore westerly transport and distribute sand along Linwood Beach. A "littoral cycle" would be formed in which hydraulic pumping or trucking of sand would augment natural processes. The details regarding maintenance intervals and quantities moved could be designed based on sand volumes presented in Section II.

Artificial nourishment of Linwood Beach from an external sand source could be combined with bypassing at the east pier. Sand would be added to the littoral system, with some benefits for shoreline residents east and west of the harbor. The major benefit would be a larger beach at Linwood. The feasibility of such a scheme depends upon the cost of outside sand.

A variety of shoreline protection structures designed to retain sand could be considered including:

1. Groin fields of various designs.

2. A system of offshore breakwaters.

These solutions would have additional environmental and hydraulic effects, and careful evaluation would be necessary.

Conclusions

The preceding analysis has shown that the offshore breakwater has contributed significantly to shoreline re-orientation, characterized by accretion near the piers and erosion at eastern Linwood Beach. However, the shoreline is approaching a new equilibrium and no further significant shifts are anticipated. It has not been possible to quantitatively determine how much of the realignment was due to high lake levels and a higher incidence of northeast winds, and how much was due to the offshore breakwater.

The breakwater has created sand deposits in the lake approach channels and the river entrance channel. Mitigation of these impacts has been practiced in the form of maintenance dredging on three occasions. Dredging or some other form of mitigation may be required in the future for removal of similar deposits.

The tradeoff between navigation protection and coastal processes impacts is apparent. Any structure that reduces wave action to aid navigation also reduces the motive force that maintains shoreline equilibrium. Only removal of the breakwater will be completely effective in returning the shoreline to the pre-1972 long term equilibrium position. Partial modifications may also be investigated, but it is doubtful if any solution which retains significant protection for navigation would do much for restoration of the shoreline.

As stated above, the offshore breakwater has provided protection from high waves at the harbor mouth, and has had an adverse impact on shoreline re-orientation and erosion at the east end of Linwood Beach. However, the apparent relative stabilization of the shoreline at its 1976

alignment leads to the conclusion that no additional significant erosion of the beach is likely. It is emphasized that minor short term fluctuations in orientation continue to occur as a result of storms, and beach width varies with lake level. The bluff may continue to erode when storms occur during high lake levels, even though the beach remains in a long-term equilibrium position. Therefore, assuming that the beach is acceptable as it presently exists, no further consideration of mitigation for beach erosion is required. It is recommended, however, that periodic monitoring of the beach be continued so that any future unanticipated re-orientation of the shoreline is promptly recorded.

Impacts Investigated and Conclusions Reached in Companion Study

The purpose of this study was to determine whether or not the detached breakwater at Vermilion Harbor, Ohio, is causing any adverse effects for which mitigation measures should be considered. The study was initiated in April 1977 in response to complaints from the Linwood Park Cottage Owners Association and other citizens concerned about specific subjects.

The seven specific subjects of complaint addressed in this report are:

a. Periodic contamination of municipal water supply.

b. Diversion of Vermilion River water into and pollution of adjacent recreational swimming areas.

c. Increased (or decreased) ice formation in the calm waters shoreward of the breakwater at the harbor entrance and increased (or decreased) probability of ice jam flooding.

d. Increased flood potential due to raising the river water profile.

e. Rapid sediment accumulation in the Vermilion River causing increased dredging costs and increased sedimentation in the adjacent private lagoons.

f. Navigation hazards due to traffic congestion at the river mouth and at blind corners.

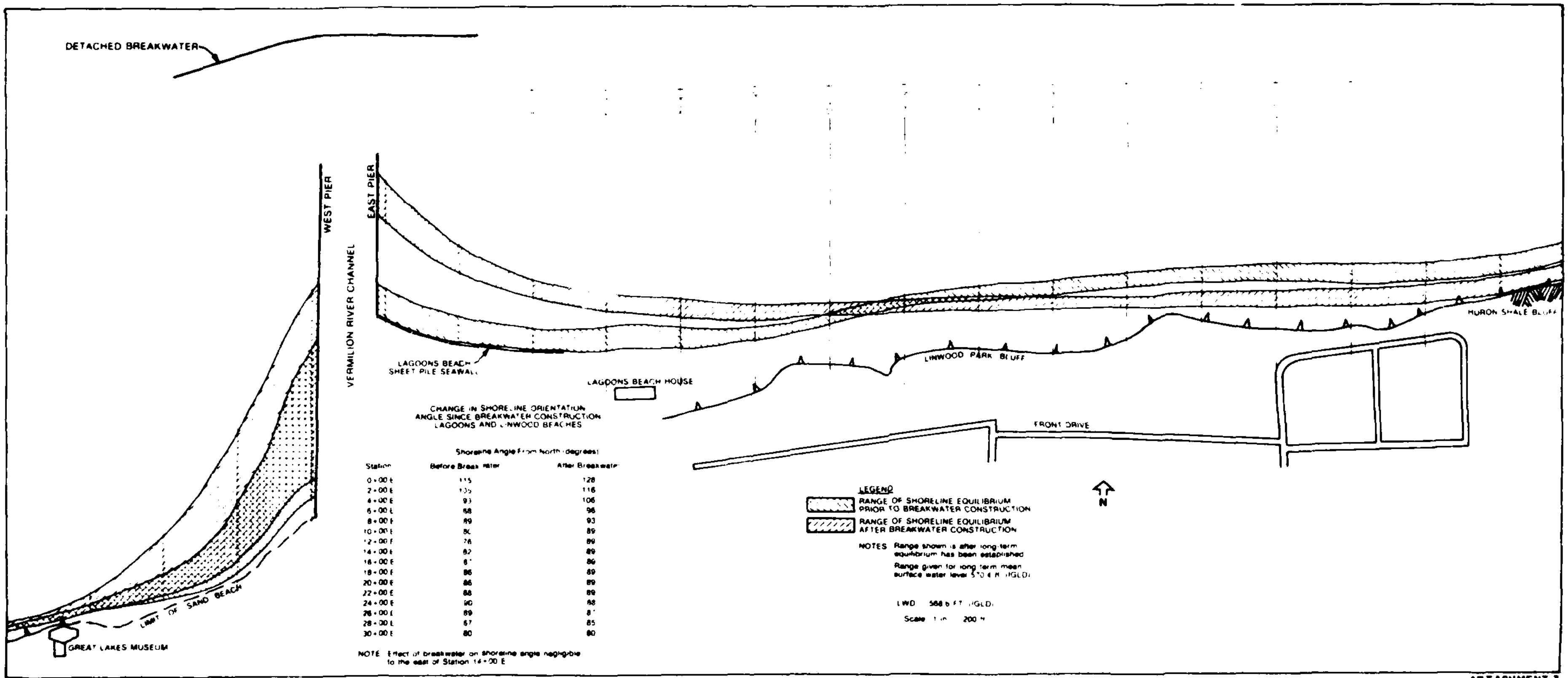
The results of this study are that the breakwater is having an adverse effect on: (1) the recreational swimming areas to the east by diverting polluted water to them; and (2) on the ice jam flooding by increasing ice jam potential at the harbor entrance. Additional studies will be undertaken to quantify the severity of these impacts and recommendation of a mitigation plan, if warranted, will be made.

Results regarding sediment accumulations in the river are related to the shoreline erosion and redistribution of sand to the east and west of the harbor. The conclusions have been presented in this Section.

It was concluded that the breakwater is not having a significant effect on the following items:

1. Periodic contamination of the municipal water supply.
2. Increased flood potential due to raising the river water surface profile.
3. Navigation hazards due to traffic congestion at the river mouth and at blind corners.
4. Aesthetics.

Therefore, no further consideration of mitigation for these aspects is warranted.



CHANGE IN SHORELINE ORIENTATION ANGLE SINCE BREAKWATER CONSTRUCTION LAGOONS AND LINWOOD BEACHES

Station	Shoreline Angle From North (degrees) Before Breakwater	After Breakwater
0+00 E	115	128
2+00 E	105	116
4+00 E	93	106
6+00 E	98	96
8+00 E	89	93
10+00 E	80	89
12+00 E	76	89
14+00 E	82	89
16+00 E	81	86
18+00 E	86	89
20+00 E	86	89
22+00 E	88	89
24+00 E	90	88
26+00 E	89	81
28+00 E	67	85
30+00 E	80	80

NOTE: Effect of breakwater on shoreline angle negligible to the east of Station 14+00 E

Figure 15 • CHANGE IN SHORELINE EQUILIBRIUM SINCE BREAKWATER CONSTRUCTION

ATTACHMENT 3

STAGE II DETAILED PROJECT REPORT

FOR

VERMILION HARBOR, OHIO SECTION 111 STUDY

SYLLABUS

TO

STANLEY CONSULTANTS TECHNICAL REPORT ON SHORELINE CHANGES

BUFFALO DISTRICT ENGINEER'S RECOMMENDATION

REGARDING FURTHER ACTION

FOR MITIGATION OF SHORELINE CHANGES

CAUSED BY THE OFFSHORE BREAKWATER

STAGE II DETAILED PROJECT REPORT
FOR
VERMILION HARBOR, OHIO SECTION 111 STUDY

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TO
SYLLABUS

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TABLES

2 August 1978
10 December 1978 (Revised)

SYLLABUS

Introduction

The Vermilion Harbor project is a Federally constructed facility whose purpose is to provide a safe harbor for recreational and commercial fishing craft. The existing harbor project provides a safe, reliable facility and satisfies intense recreational boating and commercial fishing needs in the area as expressed by the more than 900 slips at the marinas and yacht clubs and the utilization of the Vermilion Harbor by more than 6,000 boats each year. The latest Vermilion harbor improvements were completed in December 1973, and consisted of channel widening and deepening and construction of a detached breakwater approximately 300 feet offshore. Subsequent to this latest construction, there have been repeated complaints that the breakwater is causing significant shoreline changes and serious environmental, health, flooding and recreation problems in the adjoining updrift area. By letters dated 31 July 1974 and 13 December 1974, William B. Nye, former director of Ohio Department of Natural Resources, officially requested that the Corps investigate the severity of the erosion problem (shoreline changes) created by the detached breakwater under the authority of Section 111 of Public Law 90-483.

Study Purposes

The purposes of this Stage II Detailed Project Report (feasibility study) are: to quantify the shoreline damage at Vermilion due to construction of navigation works at Vermilion Harbor; to develop alternative plans for mitigating the damages if mitigation is warranted; and to determine if further action regarding mitigation of shoreline damage is required. The results from the associated analyses, and decisions reached, are presented in this document.

Studies Made

Three stages are normally required in the Corps study process under the "Continuing Authority" authorization that encompasses the current studies at Vermilion. The objective of the first stage "Reconnaissance Study" is to determine if the particular water resources problem (in this instance, shoreline erosion) is serious enough to warrant further study. The Stage I preliminary analysis is based on available information and data. In Stage II, additional data are collected, detailed studies are made to quantify the

problem, a full range of alternatives that would solve the problem is investigated, estimates of project costs and benefits for each alternative are obtained, an environmental assessment of each alternative is made, and a decision is reached regarding the engineering, economic, environmental, and social feasibilities of constructing the water resources project. Assuming that a project is recommended in Stage II, the detailed design of the "selected plan" is conducted in Stage III.

As a result of repeated shoreline erosion complaints and the request by Director Nye, a preliminary study of the alleged erosion problem was initiated in 1975. Stage I of the Section 111 study specifically addressed the effect of the Vermilion Harbor navigation works on the shoreline processes. In the Buffalo District's "Preliminary Report on Section 111 Study of Vermilion Harbor, OH, dated 21 January 1976, it was recommended that no action be taken at that time to prevent or mitigate shore damages since it could not be determined whether the recent shoreline change was caused by high lake levels or the detached breakwater; and a five-year beach monitoring program be accomplished prior to initiation of further detailed studies. Subsequent to completion of the Preliminary Report, further evaluation led to the conclusion that the five-year monitoring program would only identify short-term shoreline changes and because of very little baseline (pre-breakwater construction) data, any conclusions drawn from the monitoring program would not be highly reliable. For these reasons, the monitoring program was terminated and Buffalo District recommended that the Section 111 Detailed Project Report and the Special Impact Report Studies be initiated. In early 1977, it was decided to initiate Stage II studies of the shoreline erosion problem (Section 111 Study) and the environmental, health, flooding, and recreational problems (Special Impact Study). This Syllabus and report pertains to the Stage II investigations of the Section 111 Study. The partially completed investigations concerning the environmental, health, flooding and recreational problems are presented in a separate, companion report titled Vermilion Harbor, OH, Study of the Offshore Breakwater on: Municipal Water Supply; Swimming Areas and Beaches; Ice Jam Flooding; Free-Flow Flooding; Sedimentation Navigation; and Aesthetics; dated April 1978.

Purposes of Section 111 Study and Companion Breakwater Impact Study

The Ohio Department of Natural Resources and citizens expressed concern that the detached breakwater has caused increased shoreline erosion and redistribution of beach sand to the east and west of the harbor. The specific objective of this Section 111 Study is to determine the extent of shore damage due to the navigation works at Vermilion Harbor, and if any, to recommend whether consideration of mitigation measures is warranted.

Based on the concerns expressed by the public and a cursory evaluation of these concerns by Buffalo District, it was concluded that an Impact Study should be made. The purpose of the companion Breakwater Impact Study was to determine whether or not the detached breakwater at Vermilion Harbor, OH, is adverse to the: municipal water supply; swimming areas and beaches; ice jam flooding; free-flow flooding; sedimentation in the harbor area; navigation; and aesthetics - and after considering the degree of adversity, to decide whether consideration of mitigation measures is warranted. The Buffalo District Engineer's decision on this matter is presented in the Syllabus to the companion report, and summarized below.

It should be noted that the original objective of this phase of these two companion studies was to determine if the impacts are sufficiently adverse to warrant consideration of mitigation. The type and extent of mitigative measures were to be determined in future studies, as appropriate. Since the evaluation of alternative designs was not part of this phase, the alternative designs for mitigation would subsequently be required to complete the Stage II activities. However, as presented later in this Syllabus, Buffalo District did evaluate several types of mitigative measures, thus completing Stage II of this Section 111 Study.

Conducting the Section 111 and Breakwater Impact Studies by A/E Contract

In an effort to maintain maximum objectivity in the analyses of the effect of the breakwater, it was decided to hire a private consulting firm to conduct the investigation. Stanley Consultants of Cleveland, OH, was selected to conduct the companion studies. Principal findings of the Stanley Consultants' Section 111 Study on the impact of the Federal navigation structures on the shoreline processes (erosion and shoreline reorientation) are presented herein. The results of the Stanley investigation into the remaining seven impacts are presented in the companion April 1978 report.

Conclusions and Recommendations in the Stanley Consultants Section 111 Study

The conclusions reached by Stanley Consultants regarding the impact of the navigation structures on shoreline processes are presented in Section V (pages 41-46) of this document. To summarize, Stanley Consultants concluded that:

1. The Federally constructed improvements at Vermilion Harbor have significantly affected shoreline conditions in the Vermilion Harbor area, beginning with the construction of the parallel piers in 1836. Significant erosion of the shoreline westward of the west pier occurred within 10 years, and an accretion of 500 feet occurred to

the east of the piers during the same period. The shoreline then stabilized at an equilibrium alignment which was maintained with little significant change until 1972.

2. The offshore breakwater constructed in 1973 has contributed significantly to shoreline reorientation at Vermilion. The reorientation is characterized by accretion near the piers and erosion at Linwood Beach as shown on Figure 15 of the report.

3. The shoreline is approaching equilibrium and no further significant shifts due to the breakwater are anticipated.

4. The detached breakwater has created sand deposits in the lake approach channels and the river entrance channels.

5. Only removal of the breakwater will be completely effective in returning the shoreline to the pre-1972 long-term equilibrium state. It is doubtful that any solution which retains significant protection for navigation would do much for restoration of the shoreline to its pre-breakwater orientation.

Stanley Consultants recommended that:

1. Although initial erosion (to the west of the west pier) from 1837 to 1847 was substantial, no serious consideration of mitigation of these effects is warranted at this point over 130 years later.

2. Assuming the beach is acceptable in its present state of equilibrium, no furthur consideration of mitigation for beach erosion is required.

3. Periodic monitoring (hydrographic surveys) of the beach be continued so that future unanticipated reorientation of the shoreline is promptly recorded.

Conclusions and Recommendations in the Stanley Consultants Companion "Breakwater Impact Study" (April 1978)

The conclusions reached by Stanley Consultants are summarized in Chapter 10 of this companion document. The results of the study are that the breakwater is having an adverse impact on:

1. The recreational swimming areas to the east by diverting Vermilion River water to them; and,

2. The ice jam flooding by increasing the ice jam potential at the harbor entrance.

The study recommends that mitigation of these effects should be considered by the Corps.

Stanley Consultants also concluded that mitigation should not be considered for:

1. Contamination of the Vermilion water supply

2. Increased flood potential

3. Navigation hazards

4. Aesthetics

Results regarding sediment accumulation in the harbor were incomplete in the companion study. This is because the accumulation of river sediments in the lake approach and river entrance channels is closely tied to the shoreline erosion and redistribution of sand east and west of the harbor, which is reported on in Stanley Consultants Section 111 study. The conclusion, presented in Section V of the study is that the breakwater had created sand deposits in the lake approach and river entrance channels. This sediment accumulation was caused by wave action transporting eroded sand along the shoreline and then the breakwater causing the sand to accrete in its lee because of a reduction in wave energy. However, upon review of the sediment data taken in July 1978, the Buffalo District Engineer has concluded that the sediment accumulation in the lake approach and river entrance channels is comprised mainly of silts and clays. This sediment accumulation would be due to the deposition of river sediment as it enters the lake approach channels. Dredging has been performed on three occasions since completion of the detached breakwater in 1973. In June 1974, approximately 5,900 cubic yards were dredged from the east side of the river entrance channel and placed on the west side of the west pier. In February 1975, approximately 3,000 cubic yards were removed from the east side of the channel and again placed west of the west pier. In December 1975, about 2,350 c.y. were dredged from the east side of the entrance channel and trucked to Nakomis Beach. An additional 8,500 c.y. of silt was dredged from the east lake approach channel and open-lake dumped. The material dredged in June 1974, February 1975 and the 2,350 c.y. in December 1975 consisted of sand that accumulated at the west side of the east pier. This accumulation was caused by sand overtopping the east pier during high lake levels and heavy northeast storms during that period. Buffalo District dredged approximately 3,000 c.y. of material from the landward side of the detached breakwater in late October 1978. Thus sediment accumulation is removed by the Corps maintenance dredging program. Further, the Section 111 Study indicates that the shoreline at Vermilion has reoriented itself to a new

state of equilibrium, and as expressed by the absence of the need for dredging from late 1975 to late 1978, it is concluded that frequent dredging, particularly at the river entrance, will not be required.

Buffalo District's Findings on Stanley Consultants' Studies

This report and the companion "Breakwater Impact Study" report (April 1978) by Stanley Consultants have been reviewed by the Buffalo District Engineer, the staff at North Central Division, and the Coastal Engineering Research Center. The methodologies used by the Contractor are consistent with good engineering practice and with the content requirements established in the scope of work. Further, except as qualified below, the conclusions reached by Stanley Consultants are considered reasonable and equitable to all concerned parties, including the Federal Government.

1. Pre-Breakwater Condition. Stanley Consultants concludes that although initial erosion to the west of the west pier was substantial in the 10-year period after construction of the piers in 1837, no serious consideration of mitigation of these effects is warranted at this point over 130 years later (see page 41). Since the objective of Section 111 is to study, investigate, and construct projects for the prevention of shoreline damage attributable to Federal navigation structures, it is the Corps position that the erosion experienced downdrift (to the west) of the Federal structures should be addressed. Although total mitigation of these impacts by the piers (which occurred over 130 years ago) would not be justified so long after the fact, mitigation of the downdrift erosion should be considered. Therefore, the final Detailed Project Report (Stage III) will place additional emphasis on downdrift erosion. This aspect of the Detailed Project Report is discussed further in the Conclusions and Recommendation sections of this Syllabus.

2. Post-Breakwater Condition. Regarding the post-breakwater equilibrium range shown on Figure 15 of the Section 111 Study, it is the Buffalo District position that the lakeward limit of the post-construction equilibrium range will be further lakeward than shown during low-water periods, thus increasing the width of the post-breakwater equilibrium band. In effect, Buffalo Distict contends that lake levels can affect the beach configuration. Buffalo District, CERC, and Stanley Consultants agree that the effect of lake levels is not mathematically quantifiable. Therefore, as recommended by Stanley on page 46 of this report, periodic monitoring (surveys) of the beach should be continued and adjustments made to the equilibrium range shown on Figure 15, as appropriate.

Concurrent Section 14 Shoreline Erosion Study by Buffalo District

Buffalo District recently finalized a Section 14 Report for Elberta Beach and Linwood Park, Vermilion, OH. That report was prepared under authority of Section 14 of the 1946 Flood Control Act, as amended. That legislation provides the Corps with authority to construct emergency shoreline protection of public works such as the endangered sewer pumping station at Elberta Beach and the sanitary interceptor line at Linwood Park. The Section 14 Reconnaissance Report (dated 3 September 1977, revised 5 June 1978 and 29 December 1978) shows that recession of the bluff at Linwood Park has endangered approximately 400 feet of the sewer line. The computed average annual benefits - consisting of emergency and relocation costs avoided - are estimated to be $14,600.

The recommended plan for protecting the sewer line at Linwood Bluff is a stone revetment with an estimated average annual cost of $11,488. The benefit-to-cost ratio is 1.3.

The city of Vermilion has provided a letter of intent to provide local assurances at Elberta Beach. However, since there was considerable local opposition to the stone revetment plan from residents at Linwood Park, the city of Vermilion did not provide a letter of intent to provide local assurances for Linwood Park. The city officials requested that the two projects be separated so that construction could proceed on the Elberta Beach project and action on the Linwood Park project could be deferred. Accordingly, the Buffalo District forwarded the Section 14 Study to Corps higher headquarters for approval, recommending the allocation of funds to proceed with Elberta Beach and to delay decision on Linwood Beach until the Section 111 Study is completed. Therefore, discussion of alternatives for mitigation of shoreline damages under Section 111 Authority will address the problem of the Linwood Bluff sewer line, as appropriate.

Estimated Changes in the Shoreline at Vermilion

It is concluded by the Buffalo District Engineer that the change in long-term shoreline equilibrium presented on Figure 15 is reasonable, although it is considered an approximation (subject to change as stated above) that is expected to be affected by extended periods of extreme lake levels. Based on the observed reorientation, it is seen that significant accretion results in the area to the west of the West Pier (Station 2+00 W to 10+00 W) and from Station 0+00 to Station 13+00 E in the Lagoons Beach area, while erosion results from Station 13+00 E to about Station 32+00 E at Linwood Beach. Estimated average volumetric and areal changes due to the long-term reorientation are shown in Table A.

Table A - Estimated Changes in the Vermilion Beaches Due to Breakwater

Location	Approximate Change in Exposed Beach Area Due to Reorientation(1)	Approximate Change in Volume of Beach Material Due to Reorientation
	(Square Feet)	(Cubic Yards)
Area 1		
Vermilion City		
Beach Area	50,000 s.f. gain	15,000 c.y. gain
(2+00 W to 10+00 W)	(Includes approximately 32,000 s.f. of private beach between Sta. 2+00 W and 5+00 W)	
Area 2		
Lagoon's Beach Area	150,000 s.f. gain	80,000 c.y. gain
(0+00 to 13+00 E)		
Area 3		
Linwood Beach Area	80,000 s.f. loss	25,000 c.y. loss
(13+00 E to 28+00 E)		
Totals	120,000 s.f. gain	70,000 c.y. gain

(1) *At long-term mean water surface level of Lake Erie.*

It must be understood that the values presented above are approximations, predicated on such factors as engineering judgment regarding the slope of the in-shore beach profile, assumed average lake levels, etc.

Estimated Tangible Monetary Changes at Vermilion Beaches Due to the Breakwater

From the previous tabulation, it is seen that there is an estimated net gain in both the beach area (120,000 square feet) and volume of beach materials (70,000 cubic yards) for the post-breakwater equilibrium state. In the Corps economic evaluation for a beach erosion project, the categories of tangible damages/benefits are physical damage prevented and increased recreational (swimming, sunbathing) usage. For this Section 111 Study at Vermilion the damage/benefit categories to be considered are physical damage due to bluff recession and recreation usage resulting from gain/loss of the recreational beach.

a. Physical Damage Due to Bluff Recession - Buffalo District is currently finalizing a Section 14 Reconnaissance Report for Elberta Beach and Linwood Park, Vermilion, OH. The Section 14 Reconnaissance Report (dated 30 Sep '77 and revised 5 June '78) shows that recession of the bluff at Linwood Park has endangered approximately 400 feet of the sewer line. The resulting average annual benefits - consisting of emergency and relocation costs avoided - are estimated to be $14,600.

If it is concluded that the recession of the bluff at Linwood Park is accelerated as a result of the detached breakwater construction, mitigation of the sewer line damage could be performed under the Section 111 shoreline erosion authority as an alternative to construction under Section 14 authority, if economically justified.

In addition to beach recession due to high lake levels, the beach reorientation caused by the detached breakwater has produced an estimated loss of beach width averaging about 65 to 70 feet at Linwood Beach. This loss in beach width at Linwood does result in more frequent wave attack on the Linwood Bluff because the narrower beach does not provide as much length for dissipation of wave energy on the beach as in the pre-breakwater state. However, Linwood Bluff was subject to wave attack - particularly during periods of high lake levels and severe storms - for the pre-breakwater condition. Therefore, all of the damage to Linwood Bluff is not chargeable to the detached breakwater. In lieu of using a highly subjective statistical analysis considering coincident occurrences of storms and lake levels to determine the amount of bluff recession attributable to the breakwater, it is concluded that the prudent decision would be to assign an arbitary, but reasonable, percentage of the damage to the breakwater.

For the Section 111 Study, it is assumed that 50 percent ($7,300 annually) of the physical damage to the Interceptor Sewer at Linwood Bluff is chargeable to the detached breakwater. Some damage (loss of land) would also occur along the remainder of Linwood Bluff. Again, an arbitrary value of $2,700 annually is assigned to the remainder of Linwood Bluff, bringing the total average annual damage chargeable to the detached breakwater to $10,000. This value will be used in the economic evaluation presented later in the Syllabus. If total bluff protection is provided in the following alternatives, the full $14,600 in benefits are included.

b. Recreational Damage/Benefits Chargeable to the Detached Breakwater - For purposes of the Section 111 Study, recreational damages/benefits are measured by the estimated change in beach area due to the breakwater construction.

The increase or decrease in beach capacity was estimated based on 75 square feet of beach per person. The 75 square feet per bather at time of peak use is considered to be the minimum needed to obtain optimum benefit from a beach visit. Beach area is measured above the mean seasonal highwater on the Great Lakes. Since under peak conditions, a utilization rate of 80 percent of capacity at Vermilion was used for benefit evaluation, the expected square feet per person is actually 95 square feet per person as calculated. The 75 square feet criteria was obtained from EP 1165-2-1 dated 10 January 1975, paragraph 16-4.c(2), page A 136. For example, the increase in beach capacity for Area 1 (see Vermilion City Beach Area in Table A) would be:

Increase in Beach Capacity = Change in Beach Area - 75 square feet per space

= +50,000 s.f. - 75 s.f. per space

= 666 additional spaces for Area 1

Column 3 of Table B, below, shows the estimated long-term change in beach capacity for the three beach areas at Vermilion. To relate the change in beach area to the annual recreational benefit, an estimate of the total annual number of beach user days and the value of a user visit is required.

Weekend days and holidays are called "peak days." The number of weekend days and holidays between Memorial Day weekend and Labor Day is 33. For computation purposes, it is assumed that seven (22 percent) of these days are lost to bad weather, leaving 26 good weather "peak days." There are about 100 days in the summer season, and about 67 of these (100 days total - 33 "peak days") are "nonpeak" days. Again, assuming that 22 percent of the "nonpeak days" per year are lost to bad weather, there are 52 good weather "nonpeak" days per year. Thus, 26 "peak days" and 52 "nonpeak" days will be used for the benefit analysis.

Typically, an individual user does not spend the entire day at the beach, and is replaced by another user. Therefore, a turnover factor of 2.0 was used to represent attendance figures for "peak days." Also, a recreational facility normally is not utilized to full capacity on a given day. Based on information provided by city officials, it is estimated that there is an 80 percent utilization rate at Vermilion City Beach (Area 1) for "peak days." Buffalo District was unsuccessful in obtaining attendance estimates for Lagoons Beach and Linwood Beach from local officials. Therefore, an 80 percent utilization "peak day" rate was assumed for all three areas. Utilization rates for "nonpeak days" was assumed to be one-third of the "peak day" attendance. Based on all these factors, the estimated potential

Table B - Estimated Increase or Decrease in Annual Attendance Potential at Vermilion Beaches Due to the Detached Breakwater

(1) Peak/ Nonpeak Days	(2) Change in Beach Area (sq. ft.)	(3) Design Capacity (Bathers)	(4) Daily Turnover Factor	(5) Daily Design Load (Bathers)	(6) Utilization Factor	(7) Daily Usage (Bathers)	(8) No. of Design Days/Year	(9) Total Annual User Days
			Area 1 - Vermilion City Beach Area					
Peak Day	+50,000*	+667*	2.0	+1,334	.80	+1,067	26	+27,742*
Nonpeak Day	+50,000*	+667*	2.0	+1,334	.27	+360	52	+18,720*
							Total Area 1 =	+46,462
							Say 46,000 Annual Increase	
			Area 2 - Lagoons Beach Area					
Peak Day	+150,000	+2,000	2.0	+4,000	.80	+3,200	26	+83,200
Nonpeak Day	+150,000	+2,000	2.0	+4,000	.27	+1,080	52	+56,160
							Total Area 2 =	+139,360
							Say 139,000 Annual Increase	
			Area 3 - Linwood Beach Area					
Peak Day	-80,000	-1,067	2.0	-2,134	.80	-1,707	26	-44,382
Nonpeak Day	-80,000	-1,067	2.0	-2,134	.27	-576	52	-29,952
							Total Area 3 =	-74,334
							Say 74,000 Annual Decrease	

Col (3) = Col (2) : 75 sq. ft./space
Col (5) = Col (3) x Col (4)
Col (7) = Col (5) x Col (6)
Col (9) = Col (7) x Col (8)
*Values shown include 32,000 s.f. of private beach not open to the public immediately east of the City Beach. Therefore, the total annual user days for the public City Beach would be reduced from 46,000 to 16,600 (say 17,000 annual increase).

increase or decrease in annual attendance due to the detached breakwater would be 46,000 increase, 139,000 increase and 74,000 decrease at Vermilion City Beach, Lagoons Beach, and Linwood beach, respectively, as shown in Column 9 of Table B.

From the tabulation of Table B, it is seen that there is an overall increase in estimated annual recreational potential at Vermilion due to beach reorientation caused by the detached breakwater. However, there is a significant decrease in annual recreational potential at Linwood Beach - which from the fragmentary information available - is intensively used at present by both residents of Linwood Park and visitors who pay a daily fee to use the park facilities. Currently, user fees for the Linwood Beach are:

$1.25/car/day, plus;
$1.25/person/day over age 12
$0.50/person/day between ages 8 and 12
free for children under 8 years of age

There is no daily fee at the City Beach.

In accordance with Corps of Engineer's publication EP 1165-2-1, "Digest of Water Resources Policies," dated January 1975, Buffalo District used the following values in determining the recreational benefit (page A-136, para. 16-4c(1)) although the above charges may have been appropriate if information on visitations could have been obtained from Linwood Park Company:

Category	Daily User Fee	Vermilion Beaches in Given Category
a. Fully developed public beach	$1.20/visitor	None
b. Partially developed public beach	$0.80/visitor	City Beach at Area 1
c. Privately owned beach open to the public	$0.40/visitor	Linwood Beach (Area 3)
d. Privately owned beach not open to the public	$0.00/visitor	Private beach at Area 1 and Lagoons Beach at Area 2

Based on these standard fee values recommended in EP 1165-2-1, and the total annual user days listed in Column 9 of Table B, the resulting annual monetary recreational gain or loss due to the detached breakwater would be: $13,600 annual gain for Area 1; $0.00 annual gain for Area 2; and $29,600 annual loss for Area 3 for a total net loss of $16,000 annually as shown on Table C, below.

Table C - Estimated Monetary Recreational Changes at Vermilion Beaches Due to the Detached Breakwater

Beach Area	Total Annual User Days Gain or Loss	Value of a User Day	Annual Monetary Gain or Loss
		$	$
Area 1 - Vermilion City	+17,000 User Day Gain	.80/User Day	13,600 Annual Gain
Private beach east of City Beach	+29,000 User Day Gain	0.00/User Day	0
Area 2 - Lagoons Beach	+139,000 User Day Gain	0.00/User Day	0
Area 3 - Linwood Beach	-74,000 User Day Loss	0.40/User Day	29,600 Annual Loss

Net Recreational Loss Due to the Detached Breakwater = $16,000 loss

c. Estimated Total Monetary Changes Due to the Breakwater - The total average annual damages/benefits consisting of physical damage due to bluff recession and potential recreational usage are summarized in Table D, below.

Table D - Estimated Total Monetary Changes at Vermilion Due to the Detached Breakwater

Beach Area	Annual Monetary Gain or Loss		
	Physical Damage Due to Bluff Recession	Monetary Gain or Loss for Recreational Beach	Total Monetary Change
Area 1 - Vermilion Beach	0	$13,600 Gain	$13,600 Gain
Area 2 - Lagoons Beach	0	0	0
Area 3 - Linwood Beach	$10,000 Loss	$29,600 Loss	$39,600 Loss
Totals	$10,000 Loss	$16,000 Loss	$26,000 Loss

Demand Analysis for Recreational Swimming Facilities in Vermilion Area

The State of Ohio uses 15 Planning Regions for any planning analyses within the State. Vermilion Harbor is located in Erie County, which is one of the five counties in Planning Region 4b. The other counties are Sandusky, Ottawa, Lucas, and Wood.

The Ohio Department of Natural Resources (ODNR) analyzed 35 demographic variables for each region in order to derive the household participation rates for various recreational activities. The participation rates show the average number of times members of households engage in an outdoor recreation activity during peak periods for the year. When the participation rates are multiplied by the number of households, the number of swimming activity occasions demanded is generated. Planning Region 4b exhibits an increasing demand during the years under study - 1975, 1980, and 1990 - as shown below:

Swimming Activity Occasions Demanded

	1975	1980	1990
Annual Demand	1,354,929	1,487,457	1,745,731

Based on this projected annual demand and considering the presently available beach area in the region, the 1975 Ohio Statewide Comprehensive Outdoor Recreation Plan stated that the following needs exist in Planning Region 4b. This represents additional beach area needed to satisfy demand.

	1975	1980	1990
Total Area Required (sq. ft.)	753,000	889,000	1,151,000
Additional Beach Capacity Required (spaces)	10,000	11,800	15,300

Based on the tabulation above, the demand for additional recreational swimming area in the planning region encompassing Vermilion, OH exceeds 10,000 spaces. The number of additional spaces to be provided at Linwood Beach under Section 111 is approximately 1,100 (see Table B). The addition at Linwood Beach would satisfy about 11 percent of the total present demand. Thus, it is concluded that the additional beach area at Linwood Beach is needed and would be utilized if constructed.

Considerations Regarding Mitigation of Shoreline Damage

The detached breakwater has created a reorientation of the contiguous shoreline at Vermilion. This reorientation has caused accretion at Vermilion City Beach and Lagoons Beach and loss of beach at Linwood Beach. Overall, the net effect from the shoreline changes has been negative as expressed monetarily by the $26,000 annual loss shown in Table D. Considering the $439,000 annual navigation benefits attributable to the 1973 Vermilion Harbor Project (from the August 1971 Vermilion Harbor General Design Memorandum and updated to January 1979 price levels), it is concluded that it would be inappropriate to remove the detached breakwater solely to mitigate shoreline damages. However, in view of the detrimental effect at Linwood Beach, consideration should be given to mitigating the Linwood Beach shore damage.

On page 44 of Section V, Stanley Consultants identifies three methods of mitigation for shoreline damage if the decision is to perform mitigation. The Buffalo District position on each of these three methods is discussed below.

a. Alternative 1 - Alteration of the Breakwater - The existing harbor project at Vermilion does provide a safe, reliable facility for recreational and commercial fishing craft. The harbor does satisfy intense recreational boating and commercial fishing needs in the area as expressed by the more than 900 slips at the marinas and yacht clubs and the utilization of Vermilion Harbor by more than 6,000 boats each year. The resulting industry has a significant favorable impact on the city's economy. The detached breakwater is an integral part of the harbor project, and essential to the intended function of the existing project. Because the breakwater is required for safe and efficient utilization of the small boat harbor so important to local economy, removal or modification of the detached breakwater does not appear to be a viable alternative for the purpose of mitigating shoreline damage. However, if further studies determine that the breakwater should be altered to mitigate the adverse effects of beach pollution and/or ice jam flooding as discussed in the Syllabus to the Companion Study, further alterations to reduce the erosion at Linwood Beach would be considered.

b. Alternatives 2 through 4 - Artificial Transport of Sand:

b.1 Alternative 2, Transport from East Fillet at East Pier to Linwood Beach, Protect Interceptor Sewer at Linwood - On page 44, Stanley Consultants suggests sand accreting at the East Pier could be transported eastward to Linwood Beach. An analysis by Buffalo District indicates that the least costly, environmentally sound, means of accomplishing this work would be to use a small dredge or

jet pump and hydraulically pump the sand to the eastern end of Linwood Beach by pipeline. However, removal of sand from the East Pier would upset the approaching new equilibrium state discussed on page 45 of Stanley's study and could allow waves to overtop the East Pier during high lake levels and northeast storms, carrying sand into the navigation channel between the piers as happened in 1974-1976 after the breakwater was constructed. Also, some of the newly created beach at Lagoons Beach would be lost, and this could be unacceptable to the affected parties.

It is estimated that it would cost $2.50 to $3.00 per cubic yard for pumping the sand from the East Pier to Linwood Beach. Initial nourishment would consist of 25,000 cubic yards to restore Linwood Beach. To prevent wave attack at the toe of Linwood Bluff and therefore protect the bluff from further recession, it is estimated that the beach would have to be filled to about +8.0 feet above Low Water Datum elevation of 568.6. Approximately 10,000 cubic yards of additional sand would be required to protect the interceptor sewer. A sand pit or reservoir approximately 200 feet wide east to west and 400 feet long north to south dredged to a depth of 10 feet below Low Water Datum would be needed at Lagoons Beach to supply the required amount of sand to nourish Linwood Beach. Based on the recent experience at Vermilion and an estimate of the effect of high and low lake levels and storm frequency, it is estimated that, over the long term, approximately 50 percent of the beach fill material at Linwood Beach would be lost each year. Costs for initial nourishment are $105,000 and the annual replenishment cost would be $52,500. Based on a 50-year project life and 6-7/8 percent interest rate, annual charges would be approximately $60,000. Since this alternative does provide protection for the interceptor sewer line at the Linwood Bluff, the full $14,600 in benefits are added to the intitial $29,600, bringing the total average annual benefits to $44,200. Therefore, the benefit/cost ratio for Alternative 2 is 0.74.

It should be pointed out that the reliability of protecting the interceptor sewer at Linwood Bluff with an unstable beach such as proposed for Alternative 2 is suspect since several violent storms within a short period could erode the protective beach and subject the bluff to direct attack by wave action. Assuming that other means of protection such as the revetment proposed under Section 14 would be required, the annual benefits would be reduced to $29,600 and annual costs reduced to $42,700. Therefore, the benefit/cost ratio for restoring Linwood Beach only is 0.69.

Serious adverse effects, other than the probable need for additional maintenance dredging at Vermilion Harbor, are not readily apparent. Based on these benefit-to-cost ratios of 0.74 for protection of both the beach and the interceptor sewer and 0.69 for restoring Linwood

Beach only, either scheme for Alternative 2 are considered viable and can be further pursued in greater detail.

b.2. Alternative 3 - Transport of Harbor Dredged Material to Linwood Beach - Buffalo District also considered the possibility of placing acceptable beach-building materials dredged from Vermilion Harbor on Linwood Beach. For example, Buffalo District is scheduled to dredge approximately 6,000 cubic yards of material from the vicinity of the detached breakwater in the fall of 1978. These materials were sampled in July 1978, and approximately two-thirds was found to be predominantly silts and clays. Upon review of the sediment data, the material does appear to be polluted. However, if future dredge material is unpolluted, it could be placed on Linwood Beach. For this stage of the study, to determine the feasibility of depositing future unpolluted dredge material on Linwood Beach, we will assume that the fall 1978 dredge material is unpolluted. Our preliminary computations show that this operation would cost about \$7.50 to \$8.00 per cubic yard to dredge by clam shell and transport by balloon-tired truck or pan along the beach to Linwood Beach. Conventional dredging and open-lake disposal would cost about \$1.25 per cubic yard. Thus, the increased cost for beach disposal would be \$6.25 to \$6.75 per cubic yard. The additional cost to place the entire 6,000 cubic yards of dredging Buffalo District has scheduled for the fall of 1978 would be about \$40,000.

Because dredging has not been performed at Vermilion Harbor since late 1975, it is assumed that maintenance dredging in the amount of 6,000 cubic yards would be required every three years. Based on a 50-year project life and 6-7/8 percent interest rate, the estimated annual cost would be about \$15,000 per year. This method of partial mitigation would not provide any protection to the endangered sewer line at Linwood Bluff. Further, the monetary loss in recreational beach would not be fully recovered since approximately 25,000 cubic yards of beach material would be required to restore Linwood Beach to the pre-breakwater condition. Therefore, as shown below, the estimated annual monetary gain to Linwood Beach for disposal of dredged materials on Linwood Beach would be approximately \$7,100.

Total monetary loss for recreational beach = \$29,600

$$\text{Recreational loss recoverable} = \$29{,}600 \left(\frac{6{,}000 \text{ c.y. available}}{25{,}000 \text{ c.y. required}}\right) = \$\ 7{,}104/\text{yr.}$$

Discounting the above on a three-year basis, taking into account an approximate 1/3 loss of dredged material back into the littoral system per year, the average annual benefits would be approximately \$2,700.

The resulting benefit/cost ratio for disposal of suitable dredged materials at Linwood Beach would be 0.18. (2,700 annual benefit - $15,000 annual costs).

This alternative would provide partial mitigation of the shoreline damage at Linwood Beach while utilizing a valuable natural resource which would otherwise be lost if open-lake dumped. Access across Lagoons Beach of the balloon-tired equipment would be required, and public safety and noise pollution problems would be encountered during the operation. In addition to meeting the requirements of a Section 404 permit action for placing dredged or fill materials on the beach, the U.S. Environmental Protection Agency would have to approve the dredged material for acceptability before the sediments could be placed. A Section 401 water quality report would also be required before bottom materials to be dredged could be placed on Linwood Beach. Considering the low benefit/cost ratio, Buffalo District is of the opinion that this alternative is marginally viable considering that partial nourishment would retain a valuable natural resource in the littoral regime.

b.3. Alternative 4 - Nourishing Linwood Beach With Sand From External Source - Based on costs for the Lakeview Project, Lorain, OH, it would cost approximately $6.75 per cubic yard to truck sand to the Linwood Beach area from the nearest sand-gravel source or Lake Erie. Assuming that it is desirable to return Linwood Beach to its pre-breakwater condition, the initial nourishment would require 35,000 cubic yards of sand, including 10,000 cubic yards to provide a beach for protecting the interceptor sewer. Periodic replenishment would be required. For this preliminary evaluation and considering periods of high and low lake levels and variability of severe storms, it is assumed that approximately 50 percent or 17,500 cubic yards would have to be replaced each year. On this basis, the annual cost at an interest rate of 6-7/8 percent would be approximately $135,000. Since protection of the sewer line at Linwood Bluff would be provided, the total annual benefits are $44,200. The benefit/cost ratio for this alternative is estimated to be 0.33 ($44,200 annual benefits - $135,000 annual costs). However, it is expected that maintenance dredging of Vermilion Harbor would increase because of the supply of sand from the outside source, and additional protection to the sewer line at Linwood Bluff would be required.

Considering the low benefit/cost ratio, particularly in comparison to Alternative 2 and the expected high additional maintenance dredging for Vermilion Harbor, Alternative 4 does not appear to warrant further consideration. However, if no other alternative seems viable, this alternative will then be considered further.

c. Alternatives 5 through 7 - Construction of Shoreline Protection Structures:

Groin fields and/or additional offshore breakwaters at Linwood Beach were considered as possible mitigative measures for returning the beach to some proximity of its pre-breakwater state. In this preliminary analysis, the need for supplemental protection of the Linwood Bluff interceptor sewer line is addressed.

c.1. Alternative 5 - Groin Field at Linwood Beach, No Protection Against Bluff Erosion - Based on design of groin fields for other locations and the width of beach to be restored at Linwood Beach, it is estimated that groins would be needed about every 600 feet, and each groin would be about 250 feet to 300 feet in length. Initial nourishment in the amount of 25,000 cubic yards at a unit cost of $3 per cubic yard for sand pumped from Lagoons Beach, and an estimated annual replenishment of 8,000 cubic yards, would be required. If rubblemound groins are used, the estimated cost would be $550 to $600 per linear foot of groin. Using the higher estimates of quantities and unit costs, the initial cost for these items would be approximately $800,000. Including contingencies and design costs, the estimated total first cost would be approximately $1.1 million. Annual charges, based on a 50-year project life and 6-7/8 percent interest rate, would be $78,000 for interest and amortization and $24,000 for annual beach nourishment for a total annual cost of $102,000. Using the average annual loss of $29,600 attributable to this project as the recoverable benefit, the benefit/cost ratio is estimated as 0.29 ($29,600 annual benefits ÷ $102,000 annual costs).

Because of this low benefit-to-cost ratio, Alternative 5 does not appear to be viable from an economic standpoint.

c.2. Alternative 6 - Groin Field at Linwood Beach to Include Protection for the Interceptor Sewer at Linwood Bluff - To prevent wave attack at the toe of Linwood Bluff, approximately 10,000 cubic yards (for reasons stated for Alternative 2) of additional sand would be required initially, and annual replenishment would be approximately 3,000 cubic yards. Assuming that this sand would be pumped from Lagoons Beach at a cost of $3 per cubic yard, the additional initial construction cost would be $30,000 and the additional annual nourishment cost would be $9,000. Total first cost, including the four groins and 35,000 cubic yards of beach material would remain at about $1.1 million but the annual beach nourishment cost would increase from $24,000 to $33,000, raising the annual charges to $111,000. Exhibit 1, following, shows a plan view and typical cross sections for Alternative 6.

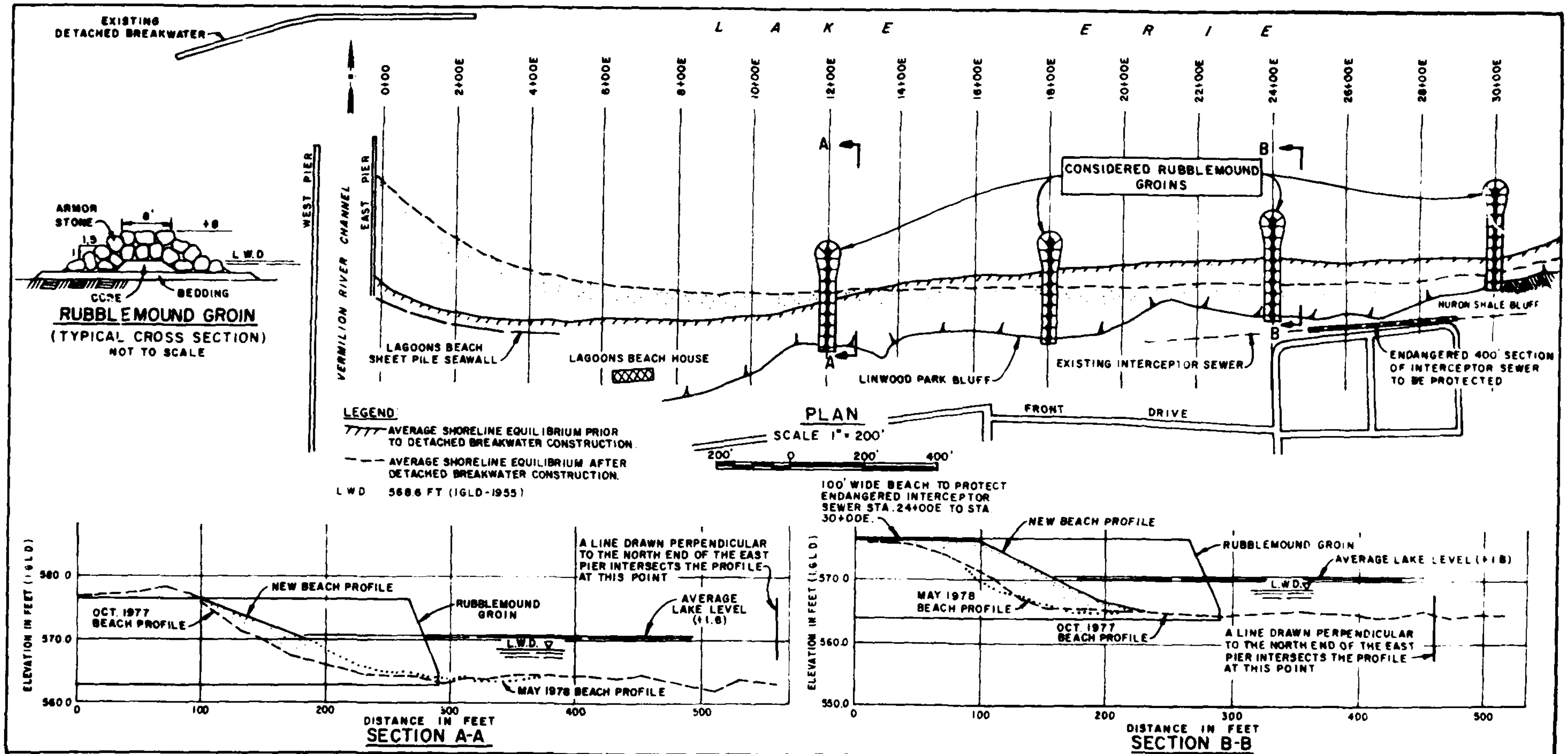


EXHIBIT I: CONCEPTUAL RUBBLEMOUND GROIN FIELD (ALTERNATIVE #6)

Since this plan would protect the interceptor sewer in addition to returning Linwood Beach to the pre-breakwater condition; the project benefits to be realized would be $29,600 for Linwood Beach and $14,600 for the interceptor sewer, for a total of $44,200 annually. The benefit/cost ratio for this alternative is 0.41. If precast concrete sections such as the Campbell Module could be used in lieu of the rubblemound groins, the initial construction cost would be halved and the benefit/cost ratio increased proportionally.

The rather massive structures on the beach would detract from the aesthetics of this recreational area. A project of this type would upset the post-breakwater equilibrium state, and in particular cause loss of beach downdrift at Lagoons Beach. Although there are a number of adverse effects inherent in a groin field project and the stated benefit/cost ratio is considered marginal for Section 111, further consideration could be given this alternative.

c.3. Alternative 7 - Segmented Breakwaters at Linwood Beach - Although Buffalo District holds the position that the state-of-the art for design of segmented breakwaters precludes a high degree of reliance regarding their intended function, a conceptual design is presented herein for comparative purposes.

Based on constructed, but as yet untested, projects at Lakeview Park, Lorain, OH and Presque Isle, PA, the individual segments should be approximately 150 feet long with a spacing of 200 feet between segments. For this preliminary evaluation, it is assumed that the 1,550 feet of affected shoreline at Linwood Beach should be protected. Initial nourishment and periodic replenishment would be required, particularly during periods of high lake levels. The beach at the toe of Linwood Bluff at the endangered interceptor sewer would be filled to eight feet above Low Water Datum to protect the sewer line.

Rubblemound breakwaters would cost about $1,000 per linear foot. As an alternative to rubblemound construction, it is considered that pre-cast concrete sections with a large base for stability could be used. The Campbell Module shown in the drawing and photographs of Exhibit 2 below will be used for this preliminary estimate. The bottom profile at Linwood Beach requires that the base of the modules be placed at approximately four feet below Low Water Datum, or elevation 564.6 (International Great Lakes Datum - 1955). The largest Campbell Module now being fabricated is six feet in height. The top of a six-foot breakwater would be at about the average Lake Erie level of 570.4.

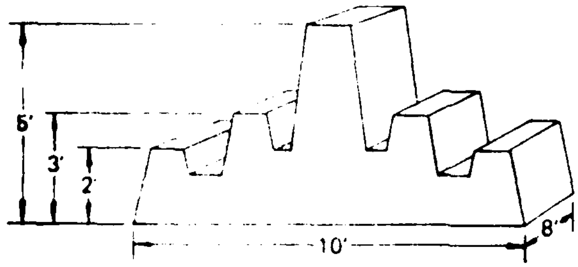
During the summer months, the six-foot module would be submerged about one foot and during periods of high levels such as 1973 to

present the top of the module would be up to three feet below Lake Erie levels and even more during storm periods with accompanying wind set-up on the lake.

There is a concern that frequent overtopping of the six-foot high module would cause excessive amounts of beach sand to be lost because of insufficient wave energy dissipation by the breakwater. The designer of the Campbell Module states that four of the five-foot sections shown in Exhibit 2 can be interlocked into a stable unit to provide a two-tiered section nine feet in total height. This section would protrude about three feet above the average Lake Erie level of 570.4. A plan view of the conceptual plan and typical beach profiles are shown on Exhibit 3, below. Each five-foot module costs about $150 per linear foot, so the four interlocked modules would cost about $600 per linear foot, in place. Therefore, the cost of fabricating and placing the 750 feet of breakwater for Linwood Beach would be $450,000. Initial nourishment would require 35,000 cubic yards of sand (including 10,000 cubic yards for the protective beach fronting the interceptor sewer at Linwood Bluff). Assuming that sand from the fillet at the East Breakwater would be pumped to Linwood Beach at a cost of $3.00 per cubic yard, the cost for initial nourishment would be $105,000. Costs for contingencies, supervision and administration, etc. are estimated at $100,000, for a total first cost of $655,000. For a 50-year project life and a 6-7/8 percent interest rate, the annual charges for these works would be $46,700. A token amount of 7,000 cubic yards of annual beach nourishment, costing $21,000 was assumed, bringing the total annual charges for the segmented breakwater plan to $67,700.

This alternative would restore Linwood Beach to approximately the pre-breakwater state and protect the Linwood Bluff interceptor sewer. Thus, the damage recoverable is $44,200 annually. The resulting benefit/cost ratio is 0.65.

Except for periods of high lake levels and severe storms, Linwood Beach can be expected to extend lakeward to the breakwaters. This may, or may not be desirable in that the beach would encroach upon the existing swimming area, and there may be a sudden increase in depth of water lakeward of the modules which could present a safety problem. The breakwaters may not be completely compatible with recreational beach usage, but the wide gaps between segments would tend to compensate for this effect. Approximately 15,000 square feet of lake bottom would be lost in accommodating the breakwaters. The low-quality discharge plume from the Vermilion River is driven onto the beaches at Vermilion under certain wind conditions. It is possible that pollution of Linwood Beach could be aggravated if the pollutants were trapped behind the breakwaters for longer periods of time than now exists. The breakwaters will trap littoral material



Patent Pending

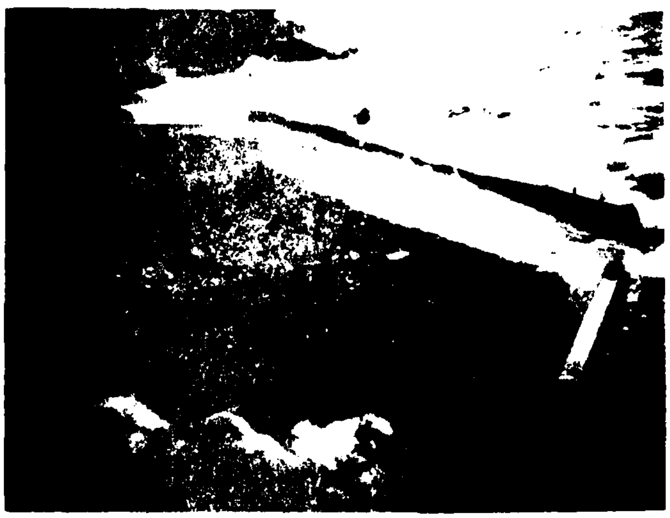
- Steel Reinforcing Bars
- 7 Sack Concrete Per Yard
- Limestone
- 2 oz. Air Per Sack of Concrete
- 4" Slump
- Approximate Weight - 14 tons
- 80 Sq. Feet at Base of
- Modules
- Larger Modules and Other Designs Available
- Also Deep Water Designs

Typical Campbell Erosion Control Module

Installation of Campbell Module at Mentor, Ohio

4 August 1973

Photo No. 1



Reclaimed Beach at Same Location as Photo No. 1 at Mentor, Ohio

16 October 1973

Photo No. 2

Drawing and Photographs Courtesy of Campbell's Erosion Control, Inc.
Exhibit 2

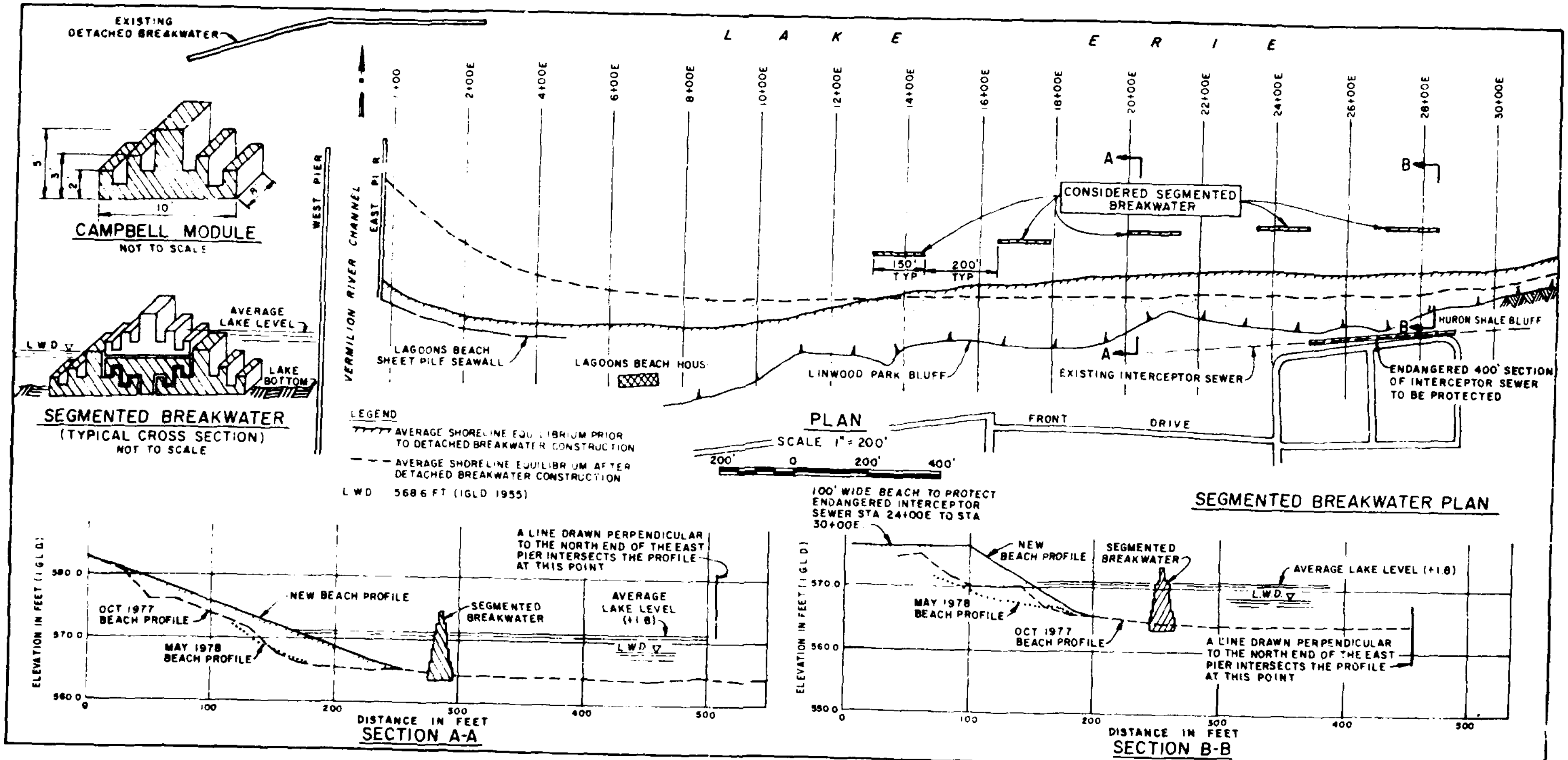


EXHIBIT 3 CONCEPTUAL SEGMENTED BREAKWATER PLAN (ALTERNATIVE #7)

and undoubtedly reduce the existing shoreline configuration at Lagoons Beach.

On balance, and considering the comparative benefit-to-cost ratio of 0.65, it is considered that the segmented breakwater alternative is a viable plan that could be considered further.

c.4. Modified Alternative 7 - To provide a range of probable costs for the detached breakwater alternative, preliminary design and cost estimates for a breakwater system nearer to the shoreline than Alternative 7 were obtained. With reference to Exhibit 3, the segments would be at the pre-breakwater shoreline except for the two westerly segments which would be approximately 30 to 50 feet offshore. At this location, six-foot high modules costing $300 per linear foot could be used. Eight segments, each 100 feet long, and spaced 125 feet apart would be required. Total first cost would be $445,000, and annual charges including annual nourishment would be $52,700. Therefore, the benefit/cost ratio for Modified Alternative 7 would be 0.84.

It should be noted that for this location, the individual modules would be placed on sand or gravel and will be subject to settlement. As previously stated, there has been very little experience with offshore breakwaters in this orientation. Consequently, a high degree of reliability regarding effectiveness cannot be associated with this modified alternative.

d. Alternative 8 - Do Nothing:

Because there has been an identifiable negative impact at Linwood Beach due to the reorientation created by the detached breakwater, it is considered inappropriate to identify the "do-nothing" alternative as a viable alternative. Therefore, no further consideration will be given to the "do-nothing" option.

Summary of Considered Alternatives

Eight alternatives were evaluated in this preliminary investigation. While the methodologies used and the quantities and costs presented are not of final design quality, they are sufficiently accurate for comparative cost purposes and to establish engineering and economic feasibility. Detailed design of the selected alternative will be undertaken in the final stage of this Section 111 Detailed Project Report.

A summary of the significant characteristics of each alternative is presented in Table E, below. From an economic standpoint, Alternatives 2 and 7 are the most favorable. However, all alternatives do present certain inadequacies, problems, and concerns,

some of which are more critical than others. Also, the possible inadequacies regarding reliability of performance are highly judgmental, and probably cannot be quantified except through construction of the given alternative.

As I stated before, the design of breakwater or groins is a state-of-the-art concept subject to many non-quantifiable variables. Any man-made structure constructed on Lake Erie will effect the shoreline processes, adverse or not. The structures built at Presque Isle, PA, and Lake View Park, OH, were experimental and are presently being monitored with the goal of learning more about the effects man-made structures have on shoreline processes. Model testing to determine the impacts that additional structures within the influence of the existing breakwater would have on shoreline processes would be required before the Corps could recommend other structures. Also, it must be noted that if any additional structures were to be built at Vermilion, the timeliness of construction is dependent upon the availability of funds.

Cost Sharing Requirements and Items of Local Cooperation

Guidance provided by Corps higher authority states that Alternatives 5, 6, and 7 would provide a degree of structural protection which is beyond the intent of the Section 111 authority. It was emphasized that since Section 111 is intended to mitigate that portion of the erosion problem attributable to Federal harbors, Section 111 projects would normally take the form of replacing a deficiency of supply of beach material attributable to the littoral barrier. Interpretation of this guidance leads to the conclusion that periodic nourishment such as proposed for Alternatives 2, 3, and 4 would be within the scope of the Section 111 authority. Of these three alternatives, Alternative 2 - pumping sand from the east pier fillet to Linwood Beach - is selected as the appropriate alternative under Section 111 authority because it would restore Linwood Beach to approximately the pre-breakwater condition using beach material already in the littoral regime at the least cost. On this basis, the costs of Alternative 4-7 that are in excess of Alternative 2 which is all Federally funded will be borne by local interests. Thus, local interests would be required to pay a portion of the cost for Alternatives 4 through 7.

Since there is not an authorized beach erosion project at Vermilion, mitigation work under Section 111 will be 100 percent Federal cost and all work in excess of that required for mitigation will be 100 percent local cost (Reference: Page A-13 of ER 1105-2-50 "Continuing Authority Program," dated 3 November 1975). Therefore, all costs in excess of the $60,000 annual cost for Alternative 2 must be borne by non-Federal interests. Based on this criterion, the Federal and non-Federal costs for Alternatives 2 through 7 are listed in Table E1. From Table E1, it is seen that the non-Federal investment would

Table E - Significant Characteristics of Alternative Plans for Mitigating Damages at Linwood Beach and Linwood Bluff

Description of Significant Considerations	Alternative 1: Remove The Breakwater	Alternative 2: Pump Sand from E.Pier Fillet to Linwood	Alternative 3: Place Suitable Dredge Material at Linwood	Alternative 4: Nourish Linwood Beach with Sand from External Sources	Alternative 5: Groin Field at Linwood, No Bluff Protection	Alternative 6: Groin Field at Linwood: Protect Linwood Bluff	Alternative 7: Segmented Breakwaters at Linwood Beach	Alternative 8: Do Nothing
Engineering Considerations: Constructibility	Viable	Viable	Risky in segregating suitable material from unsuitable.	Viable	Viable	Viable	Viable	Not applicable.
Reliability	Requires removal of entire breakwater. Partial removal only partially effective in restoring Linwood.	Would be periods during which significant recession of beach would occur. Reliable protection of Intercepter Sewer is suspect.	Only minimal restoration of Linwood Beach.	Same as Alternative 2.	Relatively reliable in maintaining restored beach at Linwood by annual nourishment. Estimated annual nourishment is an approximation at best.	Same as Alternative 5	Recommended spacing between segments is subjective. Performance of recently constructed prototype such as Lakeview Pa.,OH and Presque Isle, PA is needed before definite conclusions can be made on reliability. Say: this alternative is moderately reliable.	Not applicable.
Timeliness	Unknown	Could be performed in the near future if funds are available.	Depends on when dredging is performed.	Could be performed in the near future if funds are available.	Studies and review would take about 1-1/2 years. Construction dependent upon availability of funds which is not identifiable	Same as Alternative 5	Same as Alternatives 5 & 6	Not applicable.
Economic Considerations								
Navigation	$-439,000	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0
Recreational Beach	+ 26,000	29,600	2,700	29,600	29,600	29,600	29,600	-29,600
Bluff Recession	0	14,600	0	14,600	0	14,600	14,600	-10,000
Totals	$-413,000	44,200	2,700	44,200	29,600	44,200	44,200	-39,600
Average Annual Costs								
Project	$ 53,500	7,500	15,000	17,000	76,000	78,000	46,700	0
Maintenance & Repair	0	52,500	0	118,000	24,000	33,000	21,000	0
Totals	$ 53,500	60,000	15,000	135,000	102,000	111,000	67,700	0
Net Benefits	Less Than 0	-15,800	-12,300	-90,800	-72,400	-66,800	-23,500	-39,000
Benefit/Cost Ratio	Less Than 0	0.74	0.18	0.33	0.31	0.41	0.65	Not applicable.
Environmental and Social Considerations	Loss of some recreational activity. Partially relieve problem of beach pollution and ice jam flooding of concern to locale.	Loss of beach at Lagoons. Temporary noise pollution. Inconvenience to beach users during pumping. Additional dredging may be required due to change in beach equilibrium	Possible pollution at Linwood and Lagoons Beaches. Inconvenience to users during hauling. Noise and air pollution.	Inconvenience to Nakomis area during placement. Additional dredging may be required due to change in beach equilibrium.	Barriers on beach. Noise and pollution during construction. Loss of beach at Lagoons. Aesthetics.	Same as Alternative 5.	Same as Alternatives 5 & 6. Loss of 15,000 square feet of lake bottom for base of modules. Possible safety hazards at the breakwaters	Detrimental to mental well-being of Linwood residents who are suffering a quantifiable loss.

vary from a minimum of zero for Alternative 3 to $89,800 for Alternative 7, to a maximum of $1,072,000 for Alternative 4. Since costs for protecting the Linwood Bluff sanitary interceptor sewer are included in the costs for Alternative 2, these costs would be borne by the Federal Government for all other alternatives.

Except for Alternatives 2 and 3, which are totally within the authority of Section 111, local interests will be required to furnish assurance of local cooperation similar to those required for regularly authorized project for their assigned portion of the work. Thus, the items of local cooperation can differ somewhat dependent upon the alternative selected. Typical items of local cooperation for that portion of the project assigned to non-Federal interests are:

a. Provide without cost to the United States all lands, easements, and rights-of-way required for the portion of work above that needed for Alternative 2.

b. Contribute 100 percent of those costs for the portion of work above that needed for Alternative 2. These costs would be in the form of first cost of construction and/or periodic costs for nourishment dependent upon the alternative selected and the method of payment selected. Estimated costs shown in Table E1 are considered reasonable and representative for this preliminary investigation, but the costs for the selected alternative must be refined in the detailed design studies conducted in Stage III of this Detailed Project Report.

c. Accomplish without cost to the United States all utilities and other relocation alterations made necessary by the work above that needed for Alternative 2.

d. Hold and save the United States free from damages due to the construction works, not including damages due to the fault or negligence of the United States or its Contractors.

e. Comply with the provisions of Section 221 of Public Law 91-611, approved 31 December 1970, which provides that construction shall not commence until the local sponsor(s) has entered into a written agreement to furnish its required local cooperation.

Corps regulations (Paragraph 8e(5) of ER 1105-2-50) require that a letter of intent shall be requested for specific items of local cooperation near the completion of the current Stage II planning. Therefore, if a plan other than Alternatives 2 or 3 (which do not require items of local cooperation) is selected based upon public input, the Buffalo District Engineer will request a "letter of

Table E1 - Summary of Estimated Federal and Non-Federal Costs for Alternative 2 Through 7

Costs	Alternative					
	2* Pump Sand From E. Pier Fillet to Linwood	3 Place Suitable Dredge Material at Linwood	4 Nourish Linwood Beach With Sand from External Source	5 Groin Field at Linwood, No Bluff Protection	6 Groin Field at Linwood, Protect Linwood Bluff	7 Segmented Breakwaters at Linwood Beach
Annual Charges						
Federal	$ 60,000	$ 15,000	$ 60,000	$ 60,000	$ 60,000	$ 60,000
Non-Federal	0	0	75,000	42,000	51,000	7,700
Total	60,000	15,000	135,000	102,000	111,000	67,700
Equivalent First Costs** (6-7/8 % Interest Rate, 50-Year Life)						
Federal	869,000	217,200	869,000	869,000	869,000	869,000
Non-Federal	0	0	1,072,000	579,300	709,700	89,800
Total	869,000	217,200	1,941,000	1,448,300	1,578,700	958,800

* Costs for Alternative 2 are used as the basis for establishing non-Federal costs for Alternatives 3 through 7.

**Equivalent first costs are determined by multiplying the annual charges by the present worth factor of 14.02195 for 6-7/8 percent interest rate and 50-year life.

intent" from a responsible non-Federal public entity such as the city of Vermilion, Vermilion Port Authority, or State of Ohio before initiating Stage III design.

The specific items of local cooperation are presented in the Stage III Detailed Project Report. The signed written agreement for local cooperation must be obtained and approved by the Secretary of the Army prior to issuance of work allowance for construction. The signed agreement must be obtained after preparation of Plans and Specifications for the project.

Discussion of Damage/Benefit Categories for Linwood Beach

There are significant tangible and intangible damages associated with the shoreline reorientation at Linwood Beach. Mitigative measures to alleviate these damages would be benefits creditable to mitigation.

Tangible benefits at Linwood Beach are realized from prevention of damages, enhancement of property values, and recreational benefits. Recreation benefits for the restoration of Linwood Beach and damages prevented for protection of the endangered interceptor sewer at Linwood Bluff have been thoroughly discussed above. No consideration was given to enhancement of property values in the above preliminary evaluation. However, local residents have written to Buffalo District stating their position that restoration of Linwood Beach would enhance property values a minimum of $2,000 per property for the 40 properties at Linwood Park. They further state that a value of $3,000 to $5,000 would not be unrealistic. Assuming the minimum value of $2,000 per property, the total enhancement benefit would be $80,000. For a 50-year project life and 6-7/8 percent interest rate, the annual enhancement benefit would be $5,700. Adding the annual enhancement value to the total benefits shown in Table E produces the modified values shown on Table F, below.

Alleviation of concern by affected homeowners and improvement of the general aesthetics of this recreational community are two categories of intangible benefits to be considered. The concern of local owners at Linwood Park is extremely intense as expressed by the many letters Buffalo District has received and the numerous articles in area newspapers. Restoration of Linwood Beach would alleviate this concern.

The characteristic of the area is highly reflective of the recreational and leisure time activities associated with it. Since much of this activity revolves around the beach as a focal point, restoration of the beach most certainly would improve the aesthetics of the immediate area.

Table F - Benefit Evaluation Including Enhancement Benefits

Alternative	Total Annual Benefits Excluding Enhancement	Estimated Annual Enhancement Benefit	Total Annual Benefit Including Enhancement	Annual Costs	Benefit/Cost Ratio, Modified to Include Enhancement
1 - Alter Breakwater	$-413,000	Not Applicable	-413,000	53,500	Less Than 0
2 - Pump Sand from East Pier	44,200	$5,700	$49,900	$ 60,000	0.83
3 - Place Suitable Dredge Material	2,700	1,400 say	4,100	15,000	0.27
4 - Sand from External Source	44,200	5,700	49,900	135,000	0.37
5 - Groin Field, No Bluff Protection	29,600	5,700	35,300	102,000	0.35
6 - Groin Field, Protect Linwood Bluff	44,200	5,700	49,900	111,000	0.45
7 - Segmented Breakwater	44,200	5,700	49,900	67,700	0.74
8 - Do Nothing	-39,600*	0	-39,600*	0	N.A.

*$39,600 is for losses at Linwood Beach only. Total benefits, including accretion at City Beach and Lagoons Beach are -$26,000 annually.

Conclusions of Buffalo District Engineer on Shoreline Changes and Mitigation of Shoreline Damage

It is concluded that the detached breakwater has caused accretion of the beach areas at Vermilion City and Lagoons Beaches and loss of beach at Linwood Beach. The accretion limits established by Stanley Consultants and shown on Figure 15 are considered reasonable considering the "shadow effect" produced by the detached breakwater. However, the effect of low-water periods on the lakeward limit of the receded beach at Linwood Beach is indeterminate at this time and quantifiable only by observation during low-water periods.

Based upon the analyses presented above, it is concluded that mitigation of the loss of beach at Linwood Beach should be undertaken. Therefore, it is concluded that the "Do-Nothing" Alternative (Alternative 8) should not be given further consideration. Also, Alternative 1, to modify or remove the detached breakwater specifically for mitigation of shoreline damage, is deemed inappropriate. Each of the six remaining alternatives have both favorable and unfavorable aspects. The benefit-to-cost ratios for Alternatives 3, 4, and 5 are considerably lower than several of the other alternatives and do not appear to be viable from an economic standpoint. Also, a conclusion regarding several of these alternatives is related to the decision to proceed with construction of the Linwood Bluff revetment under Section 14, and vice versa.

As previously stated in the section titled "Buffalo District's Findings on Stanley Consultants' Studies," there is a need to consider mitigation of erosion to the west (downdrift) of the harbor structures. This analysis will be made in Stage III of this Detailed Project Report.

Recommendation

In view of the above conclusions, I recommend that:

a. Stage 3 of the Section 111 Detailed Project Report be undertaken. Therefore, the alternatives recommended for final design for mitigation at Linwood Beach are 2 and 4, or modifications thereof. This recommendation being based on the input received from the public meeting held on 31 August 1978 and the workshop held with representatives of the city, State, and concerned local private organizations on 11 October 1978. However, Alternative 4 would be implemented only if agreement cannot be reached to implement Alternative 2. Alternative 4 would involve non-Federal funding to the extent indicated on Table E1, and non-Federal acceptance of other commitments as indicated on page S-25.

b. An experimental demonstration of the Educator Type Pump system, or other similar systems, as suggested in Alternative 2 be undertaken in Spring 1979 at Linwood Beach. This will be contingent on the availability of the educator pump system from the Detroit District or other similar commercial systems, and the consent of the owners of the Lagoons Beach.

c. The need for mitigation to the west (downdrift) be investigated in Stage 3 of this Detailed Project Report.

DANIEL D. LUDWIG, P.E.
Colonel, Corps of Engineers
District Engineer